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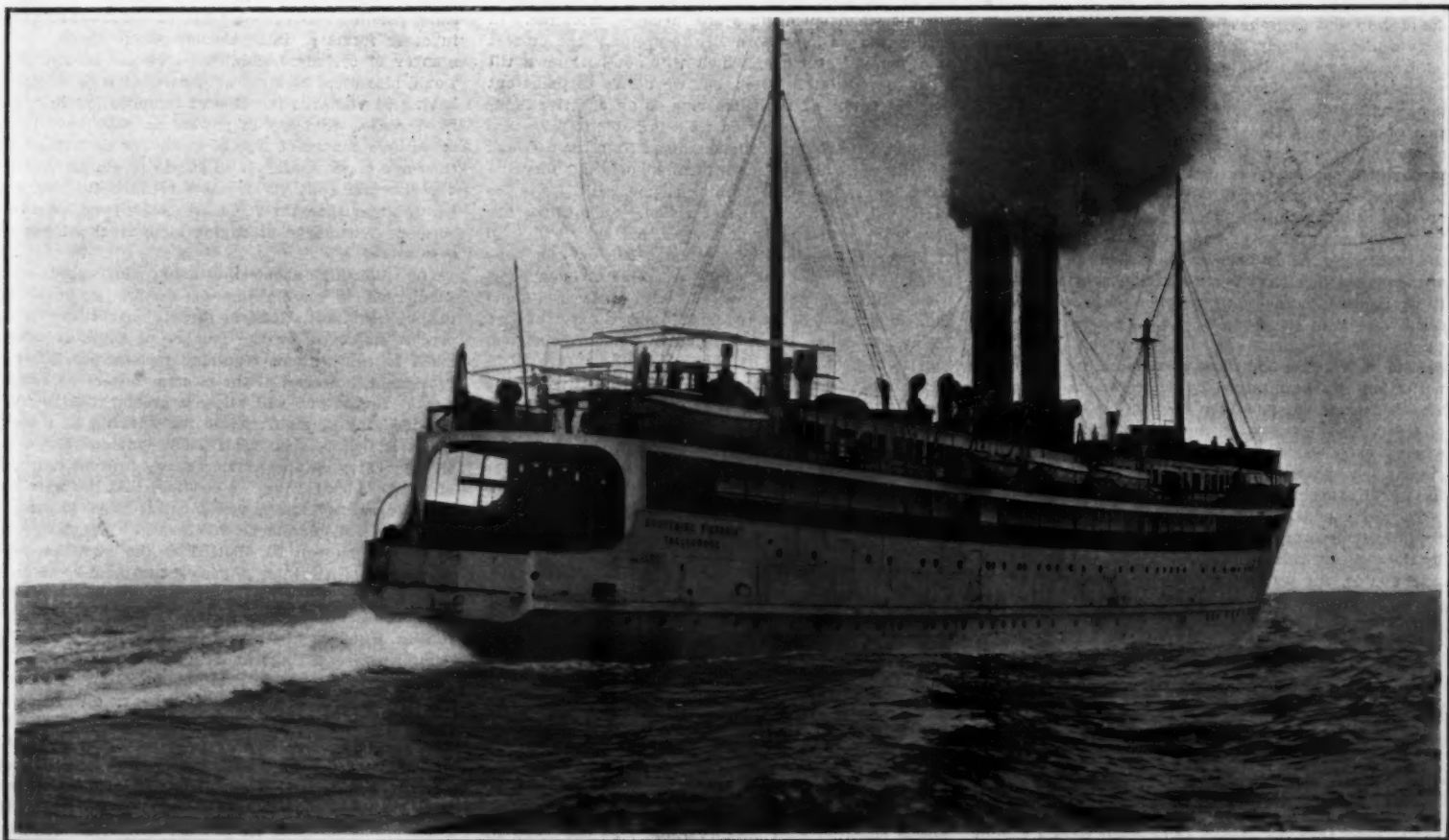
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HOW THE RAILWAY TRAINS ARE EMBARKED AND DISEMBARKED.



THE TRAIN FERRY "DROTTNING VICTORIA" UNDER WAY.
RAILWAY CAR FERRIES BETWEEN GERMANY AND SWEDEN.

A NEW KIND OF FERRY BOAT.

RAILWAY CAR FERRIES BETWEEN GERMANY AND SWEDEN.

BY F. C. COLEMAN.

A NEW service of railway-car steamers was inaugurated on July 7th by the German and Swedish governments between Sassnitz (Germany) and Trelleborg (Sweden), between which places there is a stretch of 65 miles of the Baltic Sea. For this service there will ultimately be four railway-car steamers, two provided by each country. In the accompanying photographs is illustrated the "Drottning Victoria," which has been built by Messrs. Swan, Hunter & Wigham-Richardson (Limited), of Walker-on-Tyne (England) to the order of the Swedish government. The railway-car ferries for this new German-Swedish service are of outstanding interest in so far that railway-car ferries in Europe have hitherto been confined to short stretches of inland sea, as for instance in Denmark. The introduction of the railway-car ferries has enabled a reduction to be effected in the journey time between Berlin and Christiania and Stockholm, and great developments are anticipated in transit facilities for passenger and goods traffic between the Scandinavian peninsula on the one hand and Germany and continental Europe on the other.

The two vessels of the Swedish State Railways are sister ships, and differ only slightly from those provided by the German government, which latter have been built by the Vulcan Company of Stettin. The "Drottning Victoria" is 370 feet long by 51 feet beam,

and is fitted with twin-screw triple-expansion engines, with four large boilers, working under Howden's system for forced draft. The average speed is 16 knots, which enables the vessel to cover the 65 miles between Sassnitz and Trelleborg within four hours. The design of the Swedish car ferries was prepared by Mr. William Hok of Stockholm, and in the consideration of the dimensions and proportions of the vessel, due regard was paid to the necessity of having a very steady vessel at sea. In order to add to the steadiness, deep bilge keels, 165 feet by 2 feet 9 inches, were arranged for, and these have proved their ability to minimize any tendency of the ship to roll. The trains enter the after end of the ship from a specially constructed quay and landing stage made to suit exactly the form of the vessel and so insure perfectly smooth running and safety in embarking and disembarking. A complete train of eight or ten coaches can stand on board on two parallel lines, and during shipment entire steadiness is secured by means of two trimming tanks, each of a capacity of 90 tons. A complete and substantial arrangement of ring plates and screws secures the car to the deck, and spring buffers prevent any attempt at moving endways. To add to the safety in the entering or leaving harbors, the vessel is fitted with a rudder in the bow as well as the usual one in the stern, and both these rudders

are steam-controlled from the captain's bridge, where also there are electrical indicators to show the angle at which the rudder is inclined.

The ferry is subdivided into an unusual number of water-tight compartments, which, with the Stone-Lloyd bulkhead doors, make her practically unsinkable in case of collision, and risk of danger in fog is lessened by an arrangement of submarine signals. The "Drottning Victoria" is by far and away the most representative type of railway-car ferry, and provides accommodation equaling that of a first-class Atlantic liner, for through passengers who do not choose to remain in the railway coaches while being transported over the Baltic Sea. Besides being a car ferry, the "Drottning Victoria" is built to accommodate a considerable number of passengers from coast to coast, and the vessel is provided with dining room, saloon, smoking room, lounge, ladies' room, and regal apartment, all on the promenade deck, while below the car deck there is sleeping accommodation for 96 first-class and 45 third-class passengers. For ventilating and heating there is a complete system of thermo tanks, by which the rooms are cooled or warmed according to the prevailing climatic conditions, and fresh air is constantly pumped to every part of the ship. Electric light is supplied by three dynamos, which also work the fans and hoists.

THE FUTURE OF THE SUBMARINE.

SOME PRACTICAL DIFFICULTIES.

THE lamentable accident to submarine "C 11" has again brought prominently before us the risks attendant on the use of these craft, and is the second case of disaster due to a quality which is at once one of their weak and strong points, viz., lack of visibility. The quality is a valuable one for attacking purposes, but when associated with limited vision and slow speed it becomes also a source of danger to the submarine. The history of any new branch of engineering introduced into the navy has generally been in its early days a history largely blotted over with accident and failure. Electricity, high-pressure steam, forced draft, water-tube boilers, high-speed machinery, breech-loading guns, cordite—all have claimed their due proportion of victims in the earlier stages of their development, and it may be that the submarine is passing through the same stages where accidents can be traced to lack of experience or to the want of some provision or apparatus which can only be brought to perfection by the tedious process of trial and error. In short, if the accidents—and it must be acknowledged that there are many—which have taken place in submarines are to be reduced to the same relative proportions as in other vessels of the fleet, it will be necessary to distinguish between those qualities which contain radical defects in principle and those in which a due degree of perfection can be attained by improvement in detail. The submarine has now been with us for the best-part of a decade; the crews are thoroughly trained and frequently exercised, so that we ought to be beyond the stage when accidents are attributable wholly or in part to lack of experience.

The cause of the accident to "C 11" appears primarily to have been of a simple nature. She was not seen by the vessel which ran her down, and the submarine was unable, for some cause still to be explained, to get out of the way. The "Bonaventure," which was conveying the flotilla, presumably carried the usual lights, showing that she was acting as a convoy, and the night was dark. The situation was therefore as free as possible under the circumstances from adverse conditions. The doubt is immediately raised as to whether the submarine from its nature ought to proceed in close formation, especially at night. Accidents have happened, and more frequently been narrowly averted, by merchant vessels getting "mixed up" with a fleet of large ships which can easily be seen, and it would seem that the chance of accident with a flotilla which cannot be seen is incomparably greater. We know that in this case not only was one submarine sunk, but two others were in collision in endeavoring

to avoid the steamer. The flotilla of which "C 11" was a unit was proceeding on the surface, but even thus submarines show very little above the water, and at night they are difficult to distinguish even in clear weather, unless one is specially on the lookout for them; and from this cause the ordinary rules of the road can hardly apply, and it will generally be necessary for the submarine to take the initiative in getting out of the way. This course may be rendered more difficult when submarines are in close formation. In saying this we have no desire to prejudge the present case, many features of which will not be known till after the official inquiry; but we desire to point out that the future of the submarine as an effective fighting unit depends largely on its being able to take care of itself. In avoiding collision, apart from the personal element, there are two main factors, speed and maneuvering power, and when running submerged there is the additional factor of range of vision. Submarines are now fitted with double periscopes, but even with two of these instruments, the steersman has not the same range of vision nor the same perception of distance as when using the naked eye, and with periscopes alone the submarine will always labor under a disadvantage. By an extension of the method of submarine signaling it may, however, be possible in the future to fit recording instruments in the boat which will show the distance and direction of any approaching vessel. When steaming—this is hardly the right word for vessels propelled by gasoline engines, and the submarine men themselves call it gassing—on the surface these vessels are navigated from the top of the conning tower and when not seen by the approaching vessel they must rely on their running power and speed. No results have been published of the turning circles of these craft, but from their shape they should be very quick, except that they are steered by hand, and in the larger and latest boats the work of pulling the helm hard over at full speed must be considerable. As these boats have electric power, no doubt an electric steering motor will be fitted if found necessary or desirable. It is in the speed of the submarine, both on the surface and submerged, that the greatest obstacles to development will be met. The latest boats of the "C" class have a full speed on the surface of about 13 knots, and about 9 knots when submerged, and they will prove no exception to the general rule that the power required goes up very rapidly as the speed increases, more rapidly than the cube; for larger engines and motors mean a larger boat.

We suppose the submarine could not have attained

to its present state of development without the aid of the internal-combustion engine, and to it we must look for further progress. The gasoline engines at present fitted represent about the limit of size which can be attempted with the conditions prevailing on board these craft. The diameter of the cylinders is already larger than of any gasoline engine used on shore, and cannot be increased without risk of such troubles as pre-ignition, to which there is always a tendency in engines using gasoline with cylinder dimensions much less than in other forms of internal-combustion engines. The number of cylinders employed together on one shaft would also seem as large as consistent with efficiency, having in view the increase of complication in a confined space. Increase in power can thus only be secured by a change of type of engine, or by fitting more than one screw shaft. It is generally known that the experimental boat "D 1," now being built, which is much larger than the "C" class boats, is to have twin screws. What type of engine is to be fitted has not been stated.

The difficulty about increasing the speed when submerged is mainly one of weight, as there are no practical limitations to the size of battery which can be employed, or the number of hours it can be made to run without requiring recharging. Any improvement, however, of the electric battery as regards weight for output will allow a greater weight to be provided in the main engine for working on the surface. It will be seen what a disadvantage the necessity for carrying an electric battery is from the point of view of speed, when we consider that the weight of a destroyer's machinery works out at about 40 per cent of the total displacement, whereas in a submarine the weight which can be allotted to the main propeller machinery is less than 20 per cent of the displacement, while the batteries and motors weigh nearly double this. The combination of batteries and gasoline engines is also a source of danger, though experience in the details of the fittings and care in manipulation has reduced this danger to a minimum. Many men have been working on the design of a heavy oil engine for this craft, but the conditions are so onerous, and the difficulties as compared with gasoline are so great, that up to the present no satisfactory solution has been found; but inasmuch as the dangers and disabilities of the use of gasoline will increase rapidly in larger sized cylinders than those at present attempted, it would appear that the development of the oil engine using safer kinds of petroleum is an essential factor in the development of the submarine.—The Engineer.

A SUCCESSFUL MARINE PRODUCER-GAS PLANT

A BRIEF ACCOUNT OF THE "MARENGING."

THE motor boat "Marenging," built for H. L. Aldrich, publisher of International Marine Engineering, and fitted with a producer-gas power plant, has now been in commission for over two months, and has been given a thoroughly practical try-out. As announced in previous issues of this magazine, this boat was brought out solely for the purpose of finding out whether a producer-gas plant could be used to a mean draft of 3 feet and 6 inches, and is driven by a four-cylinder, four-cycle engine, with cylinders $5\frac{1}{4}$ inches in diameter by 6 inches stroke, which turns from 400 to 500 revolutions per minute. The engine is fitted with a reversing gear, mounted in an extension of the main bed, and drives a solid three-bladed bronze propeller 24 inches in diameter.

The engine used on this boat is a regular stock motor, designed for using gasoline (petrol), the only changes made for producer gas being in the nature of considerably higher compression than is ordinarily met in gasoline (petrol) engines. The inlet and exhaust valves and piping on this engine were exceptionally large, so that no changes were necessary on these parts. For the most successful operation on producer gas, the compression in the engine should be about 150 pounds per square inch. With this particular engine it was impossible to get much over 100 pounds, and, therefore, the results were not as good as could be expected with an engine especially designed for the service.

No attempt has been made to carry out tests involving extreme refinement because the inadequacy of the engine would make such tests of little value. What has been shown, however, is the fact that marine producer-gas plants can be successfully operated with remarkable economy. This has been well demonstrated to the satisfaction of the owner and many marine engineers and naval architects who have seen the plant in operation. Compared with a steam-power plant, this boat has shown remarkable economy, averaging a horse-power an hour on slightly over a pound of coal. In regular service the boat covers between 800 and 900 miles on a ton of anthracite pea coal, costing (depending upon where the coal is purchased) between \$3.50 (14.3 shillings) and \$5 (20.4 shillings). This amount of coal covers the banking of fires and starting up at frequent intervals.

If the boat were started out on a continuous run, it is believed that it would make practically a thousand miles on a ton of coal. The average speed of the boat is between 8 and 9 miles an hour.

Such a non-stop run was attempted on July 9th, the boat leaving the Hudson River Yacht Club, at the foot of West 92nd Street, New York city, at 4:48 P. M., bound up the Hudson River to Albany and return, a distance of 275 miles. Unfortunately, considerable trouble was encountered in navigating the boat in certain parts of the river during the night, as large quantities of eel grass and weeds grow near the sides of the channel, in which the propeller became fouled a number of times, causing unavoidable shut-down. Two such mishaps on the way to Albany delayed the boat for from ten minutes to an hour each time, and the same difficulty was encountered, to a certain extent, on the return trip, preventing a strictly non-stop run. The results, however, even considering the shutting down and banking of fires, must be considered remarkable.

The summary of the trip is as follows:

July 9th, 4:48 P. M., started from Hudson River Yacht Club dock.

July 10th, 3:30 P. M., arrived first bridge at Albany.

July 10th, 3:32 P. M., started for New York.

July 11th, 10:15 A. M., arrived Hudson River Yacht Club dock.

Total mileage	275
Pounds coal burned to Albany	351
Pounds coal burned to New York	285
Total pounds coal burned for trip	636
Time to Albany	22 hours 42 minutes
Time to New York	18 hours 43 minutes
Time for entire trip	41 hours 25 minutes
Pounds of coal burned per mile to Albany	2.55
Pounds of coal burned per mile to New York	2.07
Pounds of coal burned per mile entire trip	2.31
Pounds of coal burned per hour to Albany	15.45
Pounds of coal burned per hour to New York	15.20
Pounds of coal burned per hour entire trip	15.32

One of the principal objects in view when this boat was brought out was to demonstrate to the owners of

coastwise schooners in the lumber, coal, and other trades, also to the owners of fishing boats, oyster boats, and owners of yachts requiring less than 500 horse-power, the fact that producer gas has many striking advantages over either steam or gasoline (petrol). A producer-gas plant can be installed on a fore-and-aft-rigged vessel at small expense, and can be operated at very slight cost. The cost of operation with anthracite coal costing about \$4 (16 shillings) per ton, as shown by tests made on the motor boat "Marenging," is practically one-tenth of what the cost would be if gasoline (petrol) were used at a cost of 15 cents ($7\frac{1}{2}$ pence) per gallon. As a matter of fact, gasoline (petrol) can seldom be bought at this price, and in many places it costs twice as much, so that the great economy of the producer-gas plant over a plant operated on gasoline (petrol) is evident.

As compared with a steam plant, the producer-gas plant, judging from the results obtained with "Marenging," can show a decided increase in economy over a steam plant, since a horse-power an hour can be obtained on slightly over one pound of coal; whereas in the ordinary tugboat using high-pressure steam it is doubtful if a horse-power an hour is obtained on much less than 5 pounds of coal. On large steamships and warships a steam-power plant shows, of course, better economy than a tugboat, a horse-power an hour being obtained on an average of from 1½ to 2 pounds of coal. A saving of from 25 to 50 per cent in such plants, however, means a large sum of money.

Another advantage which should recommend this type of installation as an auxiliary in coastwise schooners and the like, is the ease of operation. Any man who can take proper care of an internal-combustion engine can, without any difficulty whatever, manage a producer-gas plant. It requires little, if any, more skill to manage such a plant than it does to manage an ordinary kitchen range.

China is showing much interest in mining affairs, according to the Far Eastern Review. The government at Peking has directed the Governor of Chinese Turkestan to investigate and report on the copper deposits of Kucha and Paichang, with a view to developing them along modern lines.

AN OUNCE OF RUST PREVENTION.

SERIOUS as is the problem of rust prevention in all branches of the iron and steel industries, and in all the ramifications of those which produce iron and steel commodities, comparatively little seems to be known about the subject, and less written about it. Most of those who have been confronted with the problem feel that whatever the process may be by which oxidation of iron or steel occurs it is a dangerous foe to the metal which it attacks. Many efforts have been made to evolve a means for checking its voracious consumption of our steel and iron structures and the machinery of iron and steel by which their production is made possible.

It is known that under the influence of atmospheric oxygen, carbonic acid and other agencies, iron and steel acquire a superficial coating which results from a combination of the metal with the agent in question. Rust or oxidation will inevitably appear on iron or steel, large or small, rough or smooth, unless the surface of the metal is protected by a suitable covering of some kind. Rust forms not only on iron exposed to the air and moisture, but on iron set in brick or concrete, or under water. Everything made of iron or steel is liable to oxidation, and therefore loss in appearance and strength.

Wherever rust has once formed, its further occurrence is a natural sequence, and its prevention becomes impossible unless the affected parts are perfectly freed from all traces of oxide. The ultimate safety of a structure is not, as might be supposed, measured in the strength of large exposed members, but rather in the proper preservation of the smallest component parts, present in very large numbers in the larger members. An important function in all construction is discharged by the rivets, which unite plates, stays, and girders. If rust is allowed to gain a foothold in the rivets and screws, the rigidity of the entire structure is imperiled.

While efforts at rust prevention have been centered in the problem of preserving structures built of steel, many other interesting phases of the same problem have been claiming attention as well. One of these demands for a rust preventive came with the necessity of protecting machinery and miscellaneous shipments of iron, as finished product, during transporta-

tion to different parts of the country and in storage afterward when awaiting use. It was necessary to give the steel such a coating of water-shedding material as to form a rust-preventing, impervious layer over the surface exposed. The substances used were those least susceptible to the influence of atmospheric oxygen, and consequently with the smallest tendency to form fatty acids, because these acids attack the metal and form with it a composition of a rusty brown color. Though tallow is a fat often used for greasing the surface of iron, it is one that very soon becomes converted into a rusty brown mass, and allows the iron to rust. Mineral oils give better results than either vegetable or animal fats. A preparation which has been successfully used for years in this particular field is known commercially as Anti-Rust, prepared for the market by F. L. Melville, New York city. This product is semi-liquid in form, easily applied and not affected by changes of temperature. It is readily removed from the surface treated without resorting to the use of benzine or other cutting agents. Anti-Rust has given good results under all manner of severe tests, notably in the protection of iron from the corroding influence of salt water and in long-continued open air tests.—Railway Master Mechanic.

METHODS OF WOOD PRESERVATION.

THE constant increase in the demand for wood, which in many regions is not met by the natural growth, leads to a steady rise in the price of wood. Attempts have long been made to increase the durability of wood, which in most cases is destroyed, not by a natural process of decay, but by the action of the atmosphere and especially by the agency of bacteria and fungi. Various substances, poisonous to these organisms, have been applied to the preservation of wood.

As long ago as the eighteenth century the impregnation of wood with mercuric chloride (corrosive sublimate) was introduced by Homberg. Many analogous processes have since been devised, only a few of which have found practical application. The most important are Boucherie's process of impregnating wood with copper sulphate, Burnett's zinc chloride process, and Bethell's process of impregnation with

tar oil containing creosote. Bethell's process, with various modifications, is probably the most extensively employed of all, as well as the most efficacious, with the possible exception of impregnation with mercuric chloride.

Recently various new processes, in which fluorides are used, have been introduced, in consequence of researches made by Capt. Malenkovic, of the Austrian army. Malenkovic found that hydrofluoric acid and its salts exert a very destructive action on the organisms which cause the decay of wood. Cultures of various fungi which resisted the action of $3\frac{1}{2}$ per cent of zinc chloride and 4 per cent of copper sulphate, were killed by $\frac{3}{4}$ per cent of zinc fluoride or sodium fluoride, and by $\frac{1}{4}$ per cent of hydrofluoric acid.

These discoveries have been applied with success by the Austrian war department to the cure of very serious cases of dry rot in buildings, and by the Austrian telegraph service to the preservation of telegraph poles.

Of the various patented processes of impregnating wood with fluorides, the most interesting is the so-called neutral processes, in which mixed solutions of zinc chloride and sodium fluoride are employed. The result is the formation, in the fiber of the wood, of a basic fluoride of zinc, which in consequence of its great fungicidal power and its difficult solubility, exerts a strong and permanent preservative action.

As sodium fluoride can now be obtained for less than 5 cents per pound, it seems probable that impregnation with fluorides will be largely practised, especially in building and mining construction, where mercuric chloride is objectionable on account of its poisonous character, and tar oil on account of its offensive odor and its inflammability.

Malenkovic has discovered, also, that dinitro benzol, dinitro phenol, and their homologues possess a fungicidal power eight times that of mercuric chloride, and that these dinitro compounds and fluorides, used in conjunction, produce an effect greater than the sum of the effects of the two ingredients, employed separately. It appears probable that this combination will furnish a satisfactory practical substitute for mercuric chloride, which is not only very poisonous to human beings, but is also very expensive.—Unschau.

IMITATION ARMS AND ARMOR.—II.*

HOW TO MAKE THEM AT HOME.

BY A. ROZE.

Concluded from Supplement No. 1756, page 142.

We must now turn our attention to more ambitious work, the making of helmets, breastplates, and even full suits of armor. Of course, there is no limit to the size that the helmets or armor can be made. For instance, the reader can make his suit of armor a model one, either 15 inches in height, or life-size at his option; so with helmets or breastplates; for what-

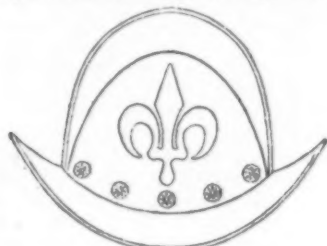


FIG. 24.

ever the size, the *modus operandi* would be the same.

Fig. 24 is a German morion, the fleur-de-lis in embossed work. On each side of the helmet is the badge of the Civic regiment of the city of Munich, and is the symbol of the Virgin, having nothing to do with the arms of the kings of France, end of the sixteenth century. To construct the following helmets and

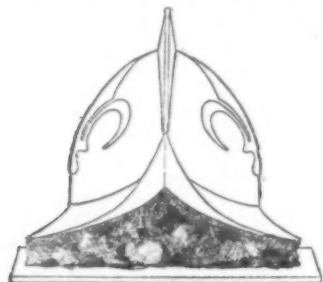


FIG. 25.

armor, a mass of clay is necessary; any kind of clay will answer the purpose, that is, if it is easily workable, and fairly stiff. It must be kept moist, and well kneaded together. A large board, or several planks joined closely together, will be required to work the clay upon. The size of the board will depend on the size of the work that is intended to be executed upon it.

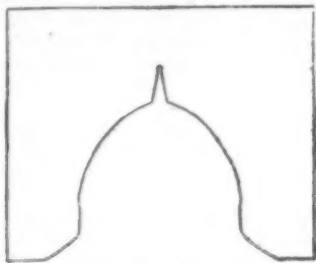


FIG. 26.

Fig. 24 is a side view of helmet.

Fig. 25 shows clay on board modeled into shape of helmet by the aid of a pair of compasses, a few clay-modeling tools, and the deft use of one's fingers, the fleur-de-lis being slightly raised, as in bas relief. To aid in getting helmet in correct proportion on both sides, and over the crest on top, cut out a shape with

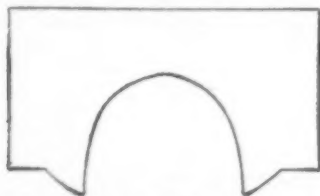


FIG. 27.

keyhole saw in a piece of wood, as seen in Fig. 26. This being passed carefully and firmly over the clay, will help to bring it into shape, and will also show where there may be any deficiencies in the modeling, which then can be easily remedied by adding more clay. The cut-out pattern, Fig. 27, is the side view of helmet, and will help to put that side into form.

* English Mechanic and World of Science.

Fig. 28 is a helmet with a movable vizor, so that it may be lifted up or down, as shown in the drawing. On the top of the helmet is a crest or comb; around the neck two layers of steel plate, which act as a gorget. These rest upon the shoulders of the warrior.

We will suppose that the clay mold is finished, and perfect in form. Now will be the time to give a thin and even coating of oil—sweet or salad oil will answer the purpose very well. By this time there must be ready some moist pieces of thin brown paper, such as are used by fancy shopkeepers to wrap up the customers' purchases. This paper should be torn up in pieces about size of the palm of the hand, and of irregular shape, soaked in a basin of water all night in which a tablespoonful of size has been melted, and well stirred. All being ready, the clay mold oiled,

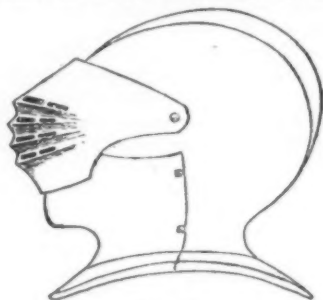


FIG. 28.

and the basin of soaked paper near to hand, take up one piece of paper at a time and very carefully place it upon the clay mold, pressing it well on the mold and into and round any crevices and patterns, and continue till the clay helmet or mold is completely covered in every part. This being done, give the paper a thin and even coating of glue, which must be quite hot, and laid on as quickly as possible. Lay on a second lot of paper as carefully as before, then another coating of glue, and so on, until there are about four to six coats of glue and paper, which, when dry,

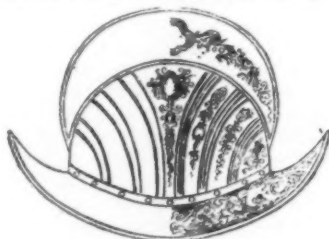


FIG. 29.

should be quite stout and strong enough for the helmet to be used for ornamental purposes. Before taking it off the mold, which should be found no difficult matter, owing to the clay having been previously oiled, trim off any ragged edges of paper with a sharp penknife, and smooth and finish off all over the helmet with some fine-grain glasspaper; then glue carefully on in sections the tinfoil, which will give it the finishing touch. When the helmet is off the mold, bore holes with a small bradawl at equal distances, through which insert some fancy brass nails, as seen



FIG. 30.

In Fig. 24, bending the nails over and flat against the inside of the helmet.

The whole helmet, with the exception of the vizor, should be modeled and made in one piece; the vizor then to be made, and fixed in its place with a brass-headed nail on each side. The oblong 'slits' in front of the vizor must be carefully marked out with pencil and cut through with a sharp penknife or small chisel.

Fig. 29, an Italian casque, for a foot soldier, six-

teenth century. It may have the appearance of being richly engraved, as shown on one half of the drawing, which would give a very handsome appearance to it, or with only a few lines running down, as seen on the left-hand side of the helmet; brass studs to decorate the band of helmet.



FIG. 31.

Fig. 30, an Italian cabasset, sixteenth century. Plentifully decorated with fancy and round-headed nails, as shown in the design.

Fig. 31, a large bassinet with hinged vizor, which comes very forward, so as to allow the wearer to breathe freely; about fifteenth century, and probably used for tilting and tournaments.

Fig. 32, a burgonet skull cap, seventeenth century; a vizor composed of a single bar of metal, square in shape, which slides up and down in an iron socket

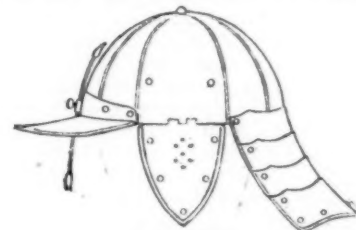


FIG. 32.

which is attached to the front of the helmet, and is held in any position by the aid of a thumb-screw, as seen in the drawing. A hole in the peak of helmet allows it to hang in front of the wearer's face. The whole of this contrivance should be made of wood; the helmet to be modeled in three pieces—viz., the skull cap, peak, and lobster-shell neck guard in one piece, the ear guards two pieces, one for each side. The middle of the ear guards are perforated with

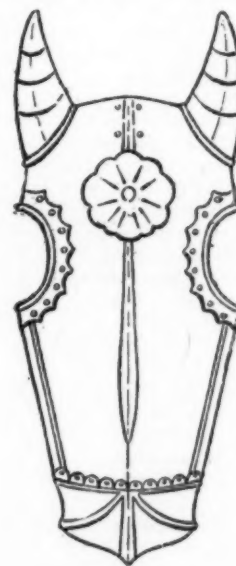


FIG. 33.

small holes. In making the above helmets the process will be exactly the same as that described for Fig. 24. They are all to represent steel in material.

Fig. 33, an open chamfron, middle of the fifteenth century. This piece of horse armor, which was placed in front of the horse's head, makes a splendid ornamental center for a shield, on which are fixed sword, etc., and a good piece for the amateur armorer to try his 'prentice hand on in the way of modeling in clay or papier maché work. The opening for the

animal to put its head into is semicircular, and the sides do not cover the jaw, it only being in front of the head; therefore the extreme depth would only be about 4 inches.

Fig. 34, a mitten gauntlet, fifteenth century. This can be made in one piece, excepting the thumb shield, which is separate; an old leather glove, fixed inside

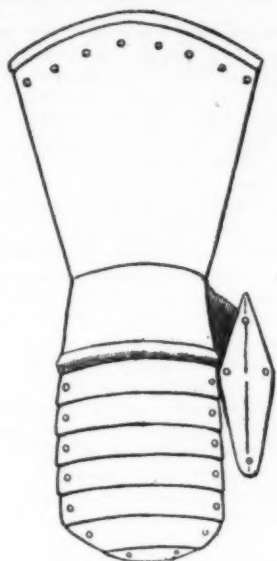


FIG. 34.

of the gauntlet by the aid of round-headed nails, will serve to fasten the thumbpiece on to. The part covering the wrist is a circular piece; but the back is not necessary, as when hanging up it will not be seen.

Fig. 35, a gauntlet, seventeenth century, with separately articulated fingers. This may be molded in one piece, except the thumb and fingers—which must be made separately, and fixed, with the thumb shield attached to the glove inside, as Fig. 34.

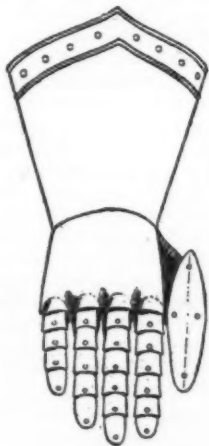


FIG. 35.

Fig. 36, a breast plate and tassets, sixteenth century. The latter are separate, and attached to the breast or front plate by straps and buckles, as seen in the drawing. There is a belt round the waist which helps to hold the back plate on to the front. Fixed to the back plate would be two short straps at the shoulder; these are passed through the buckles shown at the top right and left hand corners of front plate; but, for decorative purposes, a back plate would not be seen, therefore it is not explained here. In making imitation armor the method is the same as for the

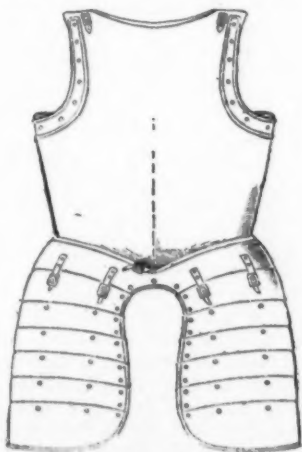


FIG. 36.

helmets, etc.; but as larger masses of clay will have to be dealt with, it is as well to economize the clay, owing to bulk and weight.

Fig. 37 shows an arrangement by which much less clay can be used. Made to the size you may require, designing a triangular-shaped support, as shown, which is placed upon the molding board or bench, and by covering this with clay, it will be found very much lighter to move about, and quite a third of the quantity of clay will be required. It is not necessary to have good and finely-planed boards; the coarser and

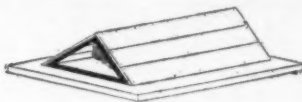


FIG. 37.

rougher the better, as they will grip the clay better. Figs. 38 and 39 show the clay modeled up ready to place the moist and sized brown paper upon, as already explained in the beginning of this article for the piece of armor, Fig. 36. The detail of the armor is not shown on these molds, as it might tend to confuse the drawing.

Fig. 40 shows a specimen of German fluted armor,



FIG. 38.

beginning of the sixteenth century. This is supposed to be in one piece, breast plate and tassets; but for convenience in making, it will be found best to make the plate and tassets separately, and then glue them together, a narrow leather belt hiding any ugly joint. Fluted armor takes its name from a series of corrugated grooves running down the armor, as seen in the design, and about $\frac{1}{2}$ inch in depth. A piece of

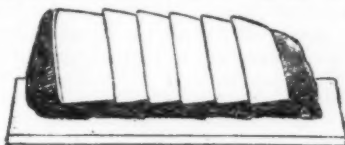


FIG. 39.

board cut into shape, as in Fig. 41, and the required size, will be found very useful to drag over the clay, thus giving a line of direction for the fluted lines, to be rectified later on with the modeling tools.

Fig. 42 is a model for a full suit of armor, of any size. The single leg shows how the armor is modeled at the side. This is the left leg. Chain mail is seen between and behind the tassets. This is represented



FIG. 40.

by sewing small steel rings onto a piece of cloth as shown in Fig. 43; the rings can be purchased at any fancy shop or ironmonger's. The whole figure when completed to stand on a square wooden box, covered with red or green baize, the armor being supported by a light framework of wood, built up as in Fig. 44. The solid black angle pieces are intended to show how and where the work is held together and strengthened



FIG. 41.

by light iron angles. The top vertical stick is to rest the helmet upon; the horizontal bar to support the breast plate, tassets, and arms. The two lower uprights for the legs, which previously must be padded to roughly imitate legs, with straw wrapped round them, then covered with red cloth or baize, finally sewing up with some stout thread. Rope, stout cord, also string will be found useful for modelling pur-

poses. For example, in Fig. 40 a sort of rope pattern will be seen round the top of the breast plate, also round the bottom edge of the tassets. It will be found very convenient to glue genuine rope on, covering well with thin glue, and, of course, finishing with the tinfoil. Sew with cord or string where a smooth line is required. Instead of brass-headed nails, brass paper



FIG. 42.

fasteners will be found very useful. These are sold at stationers' shops to hold papers together; they usually have a round head, about the size of an ordinary pencil, from which hang two brass tongues. These are pushed through a hole and opened out flat on the other side, making the stud quite secure. They

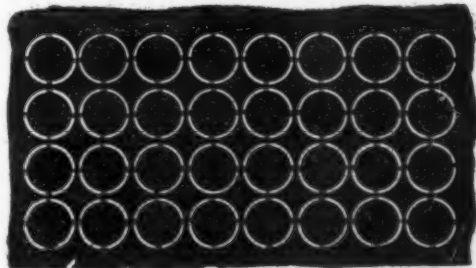


FIG. 43.

will prove especially useful in work such as Fig. 36, helmets and gauntlets.

A little pocket money, perseverance, and ingenuity should soon produce quite an interesting home-made armory, or collection of arms.

In this article, tinfoil is mentioned to finally give

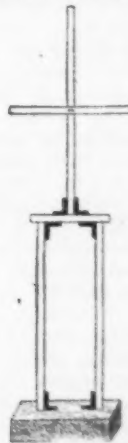


FIG. 44.

the finishing touch—i. e., to represent steel; but other materials can be used with success, such as silver paper, also silver tinsel paper, and if the above are found difficult to manipulate, go over the pieces of armor with silver paint, and when dry varnish with paper varnish—the same as used for some wall papers—using a soft brush.

OLD AND NEW ROME.

SOME RECENT ARCHEOLOGICAL DISCOVERIES.

In 1911 Rome is to be the center of the celebration of the fiftieth anniversary of the proclamation of the Italian Kingdom, and the Olympic Games are also to be held there. It is intended that an archaeological exhibition of reproductions, models, plans, photographs, etc., of the monuments of Italy and of the Roman Empire shall be held in the Baths of Diocletian, the parts of the ruins which are in private ownership being expropriated and the modern additions demolished. The Baths were in a far better state of preservation in the sixteenth century, and there are many views of them, both drawings and engravings, belonging to that period. The study of these has been undertaken as an indispensable preliminary by the Department of Antiquities; and it will also be necessary to provide the church of S. Maria degli Angeli with a façade better than the mean and unsatisfactory one which it now possesses, and which only dates from 1749, when the axis of the church was changed by Vanvitelli from that established by Michelangelo, who had in 1564 converted the Tepidarium of the baths into a church, and made this great hall the nave. Vanvitelli made the entrance through the circular Sudatorium on the south side, which had hitherto served as a side chapel, and by changing the axis, turned the original nave into the two transepts, thus much spoiling the effect.

The work of demolition of the modern buildings and additions, with which a certain amount of reconstruction will probably be necessary, has not yet commenced; and it is to be hoped that the delay which has occurred will not prevent the realization of the scheme in time for the projected exhibition.

Another important piece of work, on the other hand, which has long been projected, has now been commenced in view of this anniversary—the systematization of the so-called Zona monumentale or Zona archaeological, which is to extend from the Palatine to the Aurelian walls, including the curved southeast end of the Circus Maximus (the rest of the area of it is occupied by gasworks, which have destroyed probably the *spina* or central line of the circus, dividing the two sides of the course, which was still fairly well preserved in the sixteenth century), the site of the Septizonium, destroyed by Pope Sixtus V in 1585, and of the Porta Capena, and a large area, full of tombs, between, and on each side of, the Via Appia and the Via Latina, which diverge not far beyond the Baths of Caracalla. The scheme comprehends the formation of an avenue 100 yards in width, the portion not required for traffic being occupied either by the ruins already discovered or which will be brought to light, or by gardens. Undoubtedly the quiet, picturesque appearance of this now almost uninhabited quarter will in large measure be sacrificed. The Porta Latina and the Porta Metronia will be reopened, and will be used to give access to new quarters, which are already beginning to rise outside the walls. The work of demolition of the modern houses and buildings which occupy the site has already been commenced—demolition always proceeds quickly in Rome, where it seems to be in especial favor. It is to be hoped that proper respect will be shown to the remains of the mediæval and Renaissance buildings that may be met with, and that the construction and systematization of the new avenue will be carefully watched by the archaeological members of the commission which presides over it. There is otherwise a danger that the new work may lead to the destruction of some remains of antiquity which may be situated on the line which has been projected for it, and that others may be either buried without proper excavation or damaged by the necessary drains, etc., which will run beneath it. If the work is in any measure or sense to be completed by 1911 it does not seem that proper time has been allowed for the careful exploration of the site, which should be an indispensable preliminary to any works of a permanent character. One of the Italian papers very wisely says "to give, for 1911, a fitting arrangement to the Zona, but without destroying anything ancient and without compromising systematic explorations, this is the formula, which, in our opinion, may meet with universal approval" (*Giornale d'Italia*, June 24th). It is only to be hoped that such counsels of prudence may prevail.

The site for the Stadium for the Olympic Games of 1911 has not yet been decided upon. There has been much discussion of the question: some talked of removing the gasworks which occupy the valley of the Circus Maximus, and constructing it there; others of making use of the Circus of Maxentius on the Via Appia, and building up the missing parts (the seats, etc.) in woodwork. But it is now proposed to build a permanent structure to the north of Rome, on the

slopes of the Monti Parioli, to the right of the Via Flaminia.

The international exhibition of modern art is to be held in a gallery now under construction between the Villa Borghese and the Villa Papa Giulio—on the same side of the Via Flaminia, but rather nearer to Rome. Not far off will be the site devoted to the exhibition of modern architecture, a part of which will also find place on the opposite side of the river, near the Ethnographical and Artistic Exhibition in which the various portions of Italy will take part. Architects, both Italian and foreign, will be invited to construct houses of various kinds, both for the rich and for the working classes.

There is no hope that the enormous monument to Victor Emmanuel II, which occupies the north and east sides of the Capitoline Hill, will be completed in 1911. It was begun in 1880, but, after the financial crisis of 1889, work on it was suspended for many years, and has only been recently resumed. In order to render it more visible, and to clear the area in front of it, it will be necessary to demolish the so-called Palazzo di Venezia, an addition to the Palazzo di Venezia, dating from the fifteenth century; this will, however, be reconstructed on the other side of the Piazza di San Marco, on a site which has already been cleared. A magnificent monograph on the Palazzo and Palazzo di Venezia, by Dr. Hermann Egger and others, has just been published by the Austrian government, to which, as heir of the Republic of Venice, the palace belongs, serving as the residence of the Austrian ambassador to the Vatican.

Turning to the excavations of the Roman Forum, we may notice that Comm. Boni's activity has recently been transferred to a small building on the right of the prolongation of the Sacra Via from the Arch of Titus to the Colosseum, just beyond the foundations of the temple of Jupiter Stator, as reconstructed under the Empire, and, therefore, beyond the limits of the Forum proper.

This building is of curious plan, being rectangular, with an apse at each end. By some archaeologists it has been associated with the baths of Elagabalus (218-222), by others identified with the Church of S. Cesareo in Palatio. The latter identification has been disproved only recently, since the Villa Mills on the Palatine passed into the possession of the government, by the discovery, in a small rectangular room on the ground floor, of Christian frescoes of the fifth century A. D. The walls of the room are of brickwork of the end of the first century A. D., and it formed originally a part of the residential portion of the palace of Augustus (*Domus Augustana*) as restored after the fire of Nero by the Flavian emperors.

In the building by the Sacra Via, Comm. Boni has recently discovered a staircase, contemporary with the rest of the building, but leading down to a well of the Republican period. The water of this well was evidently, from the objects found there, believed to possess healing properties even in the middle ages—as was also the case with the fountain of Juturna, in which numerous mediæval jugs were found.

The excavations on the Janiculum have proceeded a good deal further since the last account, which appeared in the Builder (March 6th, 1909).

Remains of the earlier temple—no doubt that built by Galenas himself—have come to light at a lower level and a different orientation. It has been found that the axes (the *cardo* and *decumanus*) of this temple were delimited by a kind of path, on one side of which were round-bellied amphoræ laid sideways, and on the other long narrow amphoræ placed endways. The sacred spring lay on the line of the *cardo*, and its water was conducted in terra cotta pipes through the sacred area; an inspection shaft for the conduit is still preserved.

One of the thresholds of this building has a tile bearing a stamp of the period of Commodus, which fixes the date accurately. To this building belong also some mosaic pavements with rough black-and-white cubes, and a channel for the ritual ablutions necessary in connection with the cult.

The recent excavations at the Church of S. Crisogono, on the right bank of the Tiber, have led to the discovery of interesting remains of the older church of the fourth or fifth century A. D., which was situated on the west side of the present building (which itself dates from the twelfth century), the apse falling under the modern sacristy. It is at a considerably lower level, having been built, as is the case with S. Cecilia and other churches, into the remains of the actual house inhabited by the saint; brick walls of the Roman period belonging to this may still be seen.

So far the apse, which lies at the north end, has

alone been excavated, with the *confessio* or crypt containing originally the tomb of the saint. In the corridor leading to the window (*fenestella*) which gave a view into the crypt from the passage which follows the curve of the apse under the original floor level,* are some paintings, perhaps belonging to the eighth century: one panel represents two male saints, one youthful, the other older (probably S. Chrysogonus and S. Rufinianus) standing between two twisted columns, while in the next is a female saint, with her robe decorated with stars, perhaps S. Anastasia. Three steps ascend from this passage to the level of the church, and close to the head of them are some fragments of the perforated marble screen of *transenna*.

On the wall of the apse to the left are more paintings, of a decorative character, imitating, it would seem, the marble and mother-of-pearl inlay, which once decorated the walls of such a church as SS. Cosma e Damiano in the Roman Forum, and may still be seen in the Cathedral of Parenzo. One circle looks as though it had served as a model to the designers of the "Cosmatesque" pavement of the upper church. A small "Cosmatesque" tabernacle has indeed been found in the lower church.

On the right of the apse is a chapel with marble pavement of the sixth (?) century A. D., with disks of porphyry set in smaller pieces of marble. This was used as a place of burial, and several sarcophagi were found in it—one marble one with a group of Nereids on the front in relief and the bust of the deceased in a shell in the center, and others in terra cotta.

An important fragment of the "Servian" walls, already known to archaeologists, has recently been rendered visible for a greater extent by the demolition of the Villa Spithover on the Quirinal Hill. It is built, not of the usual blocks of red or brown tufa two feet in height, but of smaller, almost slablike blocks, about a foot or a foot and a quarter high, of the green-gray tufa known as *capellaccio*. This material is found in various buildings which may be attributed to the fifth century B. C., such as the foundations of the original temples of Castor and Pollux, of Saturn, and of Apollo, in the lowest foundations of the shrine of Venus Cloacina, in the lowest pavements of the Lacus Curtius, etc.

Remains of similar walling have also been found in connection with other parts of the Servian wall, and may belong to its original form; while the parts constructed of blocks 2 feet in height would then belong to a later date, possibly to a reconstruction after the sack of Rome by the Gauls in 390 B. C.

One of the most important artistic events of recent years in Rome was the opening in April of the new picture gallery of the Vatican. It occupies seven large, well-lighted rooms on the ground floor, with vaulted ceilings decorated with white stucco, and walls lined with an olive-green fabric, with a simple wood window frame and dado. The windows are on the east side and look on to the Cortile di Belvedere, but the gallery is approached from the road leading to the Museum of Sculpture, and comprises not only the contents of the former Vatican gallery, but the best of the older pictures from the Lateran (the modern works having been left there), a considerable number of works (especially the so-called "primitives")† from the Christian museum of the Vatican and from the library, and from the Pope's private apartments, and, finally, several pictures, discovered in storerooms or elsewhere, which were hitherto entirely unknown. It is a pity that the pictures of Giotto and the angels of Melozzo da Forlì from the sacristy of S. Peter's have not been added to the collection; and it may be hoped that it will not be long before this is done. Certainly, however, it will be some while before the center piece of the old apse of the Church of SS. Apostoli, to which these angels also belong, comes from the Quirinal Palace to join them. It has also been truly remarked that when space was scarce it was a pity to sacrifice a large room in the center of the line by turning it into an entrance hall, when the smaller room at the end, devoted to foreign painters, would have done just as well, and have obviated the necessity of returning through the first four rooms to reach the last three.

The first room contains the primitives, among which are several novelties; the second the works of the fifteenth century (the most remarkable of which is Melozzo da Forlì's fresco representing the foundation of the Vatican library by Sixtus IV., now placed in a far more favorable light than in the old gallery); the

* In the walls of this curving passage some small holes may be seen, which probably served to contain the lamps of visitors.

† The collection of Byzantine pictures from the library, a considerable number of which appeared in the exhibition at Grottaferrata (see the Builder of June 3rd, 1906), will be placed in an eighth room which is not yet arranged.

third the school of Umbria and the Marches, among which are several new works, notably a Madonna by Francesco, the son of Gentile da Fabriano, of whom only one other work is known; the fourth the works of Raphael, his father Giovanni Santi, and his master Perugino, containing entirely works already well

known, but better arranged and lighted than they were in the old gallery.

The fifth room is devoted to the Venetian school (one of the most important of the new pictures is Paris Bordone's St. George and the Dragon); the sixth to the artists of the seventeenth century (including

some important novelties); and the last to the artists of foreign schools, containing a curious mixture of works—a fine and hitherto unknown *pietà* of Lucas Cranach, Murillo's "Marriage of St. Catherine," and Sir Thomas Lawrence's portrait of George IV.—The Builder.

THE ELECTRICAL PROPERTIES OF FLAMES.

A SUMMARY OF PROF. WILSON'S STUDIES.

On the 12th instant (February, 1909) the discourse at the Royal Institution was delivered by Prof. Harold A. Wilson, D. Sc., F. R. S., of King's College, London, on "The Electrical Properties of Flames." Without assuming any special knowledge on the part of his hearers, the lecturer succeeded in elucidating the analogies between the general discharge phenomena in gases, in flames, and in salt solutions; electric discharges through flames Prof. Wilson has made his particular study for some years at Cambridge, and afterward at London.

The conductor plate of an electrometer, Prof. Wilson showed, was quickly discharged when the flame of a Bunsen burner was held near it, and less rapidly when held a few inches above it. The gases in the flame were supposed to be split into positive and negative ions, and a positively charged conductor might become discharged either by letting its positive electricity escape or by attracting the negative particles in the flame. That the latter was the correct explanation was proved by placing a plate of mica on the charged conductor. That had no direct effect. When the flame was approached, the electrometer pointer went slowly down, as if part of the charge really had escaped; but when the mica was taken off, the electrometer rose again, showing that the mica acted as a condenser; the ions were still attracted through the mica, but were stopped on the surface of the mica. On replacing the mica on the conductor the electrometer went down again.

That the ions rose up with the stream of hot gas from the flame was demonstrated in the next experiment. Within a vertical tube three insulated metal cylinders were fixed along the axis, the cylinders being at some little distance apart. From each cylinder there projected through an insulated sleeve in the side of the tube a bent wire, from which a pith ball was suspended. The three cylinders were electrically charged. When a burning spirit lamp was placed under the tube, the bottom cylinder was quickly discharged, and then, more slowly, the middle cylinder, and the top cylinder still more slowly. That experiment demonstrated that most of the ions were consumed in discharging the first cylinder, and, moreover, that they recombined and lost their mobility as the gas cooled. In the third experiment an induction coil had two spark-gaps, an ordinary cold-air gap and two Bunsen flames, and it resulted that the discharge preferred to bridge a long burner gap, traveling up one flame, then sparking across to the other from tip to tip, and going down the other flame, rather than jump a short gap in cold air. Here the few ions produced in the flame were not sufficient to carry the powerful spark discharge, and the applied potential had itself to ionize the air. The effect really depended, in this case, upon the density of the air. The hot-gas gap was about seven times as long as the cold-air gap, and the same potential also sent a spark through

a bulb seven times as long as the cold gap, but filled with air of one-seventh the ordinary density. The temperature of the flame was about 2,000 deg. C. absolute, that of the room 300 deg. C. absolute, giving the ratio 7 : 1; the figures could not be accurate, of course, since the gas flame consisted largely of coal gas and not of air. When the two Bunsen flames were burning close to one another they would touch under the electric discharge, and no sparks could then be sent through the cold-air gap.

In the subsequent experiments Prof. Wilson made use of a wide insulated gas flame, 50 centimeters in width, 10 centimeters in height, produced by placing a large number of vertical quartz tube burners—in the former experiments the tubes had been of metal to serve as conductors—by the side of one another. By inserting into the flame two platinum electrodes attached to sliding stands and joined to a battery with a galvanometer in series, and by the further use of two platinum wires joined to a quadrant electrometer, which would indicate the difference of potential of the flame between any two points, he proved that the relation between the current i and the potential V was $V = A i^2 + B d i$, where d was the distance between the electrodes and A and B were constants. If the d amounted to a few millimeters only, $B d i$ would be relatively small (except for very small i), and $V = A i^2$; i. e., the current was almost independent of the length of the flame-gap then. In the first experiments shown with this arrangement the exploring wires were not wanted, and it was proved that the current through the flame was doubled when fourfold the number of cells was put in circuit; the volt-ampere curve was a parabola—not a straight line, as in the case of a wire. With the aid of the exploring wires it was afterward demonstrated that the fall of potential was not at all regular along the flame. Starting from the positive electrode, there was a slight fall; the potential then kept nearly constant until close up to the negative electrode, when the potential fell abruptly to zero. Thus nearly all the electromotive force was used up—in the flame as in a vacuum bulb—near the cathode, where the resistance was concentrated. The two streams of ions were moving in opposite directions, and the negative ions or electrons traveled much faster (10,000 centimeters per second for one volt per centimeter) than the positive ions, which moved only at about one-hundredth of the just mentioned rate. Close to the positive electrode, the anode current would practically be carried by the negative ions; hence the high potential there.

With clean electrodes, Prof. Wilson continued, the flame current was very small; but various substances placed on the electrodes increased it. The case was analogous to the conductivity of water, which when pure was almost an insulator, but became a fairly good conductor when salt was dissolved in the water, in which it dissociated into ions. When a bead of

salt (potassium carbonate was used) was held in the flame, the current might increase considerably. But it all depended upon the position of the bead with regard to the electrodes. The increase was only observed when the bead was close to the cathode, showing again that the main resistance was encountered close to the negative electrode. In any other portion of the flame the bead would locally diminish the resistance without much affecting the total current. When the salt was put on the cathode itself, the abrupt potential drop there almost vanished, and the potential gradient became practically uniform. When afterward more salt was volatilized in another portion of the flame—which had had very little effect previously—the current was noticeably increased. Such salt electrodes could be used as rectifiers for alternating currents, the resistance of the flame being much smaller when the salt electrode was cathode than when anode.

Prof. Wilson next showed a table summing up the results of a long series of his measurements concerning the electric conductivity of alkali-salt vapors. The salt vapors flowed with a current of air along a platinum tube, heated in a gas furnace; an axial electrode was fixed in the tube, and the current was measured as passing from this electrode through the vapor to the tube. With electromotive forces of about 1,000 volts and at temperatures of 1,400 deg. C. and more, the current was proportional to the amount of salt passing through the tube and for different salts in equal quantities inversely proportional to the electrochemical equivalent of the salt. The product of current into equivalent gave the fairly constant value 2.67, and that signified that the quantity of electricity carried per molecule of salt was the same for all salts. That quantity was also found to be the same as in electrolyzed salt solutions, and thus it was established that Faraday's law holds for salts in the state of vapor, as well as for salts in solution—an important generalization of modern electrochemistry, which we largely owe, we should repeat, to Prof. Wilson's own work.

From this analogy between salt vapors and salt solutions, the lecturer concluded, we should expect the sodium ions to travel toward the cathode in a vapor flame, as they did in a salt solution. He put some sodium chloride on one of two wires, joined to an induction apparatus. The yellow sodium flame appeared only when the salted wire was the cathode. (The ordinary spark passing along a flame formed a bluish band.) This experiment proved that the positive ions (moving toward the cathode) contained the metal sodium as in a solution. But the analogy did not apply to the negative chlorine ion, which, in salt solution, collected at the anode. The negative ions in flames always seemed to be electrons, the negative corpuscles of very small mass, moving with a hundred times the velocity of the positive ion, which was an atom or a molecule.—From Engineering, London, Eng.

MEDICAL FEES IN OLDEN TIMES.

UNDER the above title Mr. D'Arcy Power has recently contributed to Janus an interesting little paper on the emoluments of physicians at various periods. With the art of a practised writer he at once arrests his reader's attention by reminding him of two physicians whose custom it was never to receive a fee at all—namely, the "unmercenary" saints Cosmas and Damian. At the opposite extreme comes the fee which Mr. Power has omitted to recall—namely, that received by Democedes of Crotona, who as a prisoner was in the service of Darius Hystaspes at Susa. Darius had dislocated his foot at the ankle-joint and Democedes was called in after the failure of an Egyptian surgeon. His treatment was successful, and he was thereupon presented with two golden fetters, a delicate allusion to his position. Having delighted Darius by asking him "whether he meant to double his punishment," that monarch told him to go through the harem as the man who had saved the king's life. The ladies each gave him a golden vessel piled up with *staters*, so many of which fell on the floor that the slave who conducted him made a handsome fortune by picking them up. He was afterward called

in to treat Atossa the Queen for a mammary ulcer which he succeeded in curing. Such patients, however, as the Great King and his consort did not fall to every man's lot, though in quite modern times the high feudatory princes of India have paid comparable fees. In the middle ages men were more mercenary, and Mr. Power gives an amusing quotation from John of Arderne (*circa* 1370) as to the methods of bargaining with a patient. Arderne's highest fee for the cure of *fluor albus* in a woman was £40 down, a suit of robes, and 100s. per annum during the life of the patient. Patients in the middle ages were no more ready to pay their fees than now, and Gilles de Corbeil, a celebrated twelfth century physician, points out in language which must surely strike an answering chord in the heart of the present Chancellor of the Exchequer, that the rich man must pay in accordance with his wealth, though he adds as a saving clause "if his mind is as wide as his purse" then—

"Aggravet hic medicina manum: sumptus onerosos
Exigat: hic positos debet transcendere fines."

In another place he remarks that it is as well for the

physician to demand his fee before the patient is well—

"Tutus esse reor, quod certe novimus omnes,
Dum dolet accipere, vel munere posse carere."

Mr. Power concludes his paper with an account of eighteenth century fees. Physicians like Radcliffe and Mead charged a guinea; country apothecaries charged much less and made their money chiefly by the sale of medicine. Mixtures, as Mr. Power reminds us, were sent out as draughts in one-ounce phials with a cork which sometimes had one pill in a box stuck on to it. Draught and pill cost 1s. 9d. As many of our readers will remember, the directions were written on a slip of paper attached to the neck of the bottle, and such a draught in the half light of a sick room bore a ludicrous resemblance to the human inhabitants of a Noah's Ark as manufactured in about 1860, up to which time the custom of separate draughts endured. Readers of Swift will remember the story he tells of Stella. "A Quaker apothecary sent her a phial, corked; it had a broad brim and a label of paper about its neck. 'What is that,' she said, 'my apothecary's son?'"—Lancet.

ANTS AND BEES AS PETS.*

A CURIOUS HOBBY FOR AMATEURS.

BY PERCY COLLINS.

In recent years many persons have been hard at work with the object of making nature study simple and easy. They have foreseen that if it were possible to devote a few odd minutes at any time of the day to observing plant or animal life, and this without passing the door of one's study or sitting-room, thousands of individuals would gladly avail themselves of such a chance. In a word, the aim of these workers has been to bring Nature, as far as may be, into the lives of those whose daily duties will not allow them to go to her. Of the wonderful success which has attended these efforts space will not permit me to write in detail. Suffice it to say that there are all manner of contrivances by means of which plants and animals of many kinds may be grown and reared in captivity, and this without any serious loss of time on the part of their owner. But perhaps the most wonderful inventions of this kind are devices for keeping ants and bees as pets. Thanks to the experiments of Avebury, Fields, and others, it is now a simple matter for anybody who may be so disposed, to observe the ways of these insects.

Let us suppose that the reader wishes to keep under observation a colony of any small species of ground ant—say the little yellow field ant. A snug home may be contrived for the insects out of an ordinary photographic printing frame. The first thing to do is to weaken the spring clips somewhat, by bending, in order to ease the pressure when the frame is closed. The reason for this precaution will be apparent shortly. Now get two clear sheets of glass, half-plate size, and three narrow strips that will fit together between the big sheets as shown in the diagram. The thickness of these narrow slips is an important consideration. They must be just thick enough to allow an ant to crawl about between the two big sheets of glass. If they are thicker than this the ants are liable to pile up grains of earth, and thus obscure the view of their doings.

Now cut a notch in the side of your printing frame right down to the flange upon which the glass rests. Then put in the lower sheet of glass, arrange the three narrow strips upon it, and you will be ready to capture your ants, and transfer them to their new homes. This is more easy to talk about than to accomplish, and the reader will probably make one or two abortive attempts before he succeeds. Rapidity is the great thing.

Take your "cage" into the open, then stir up the ants' nest, and quickly transfer to the sheet of glass as many ants, larvae, pupae, etc., as you judge will be accommodated when the second sheet of glass is put into place and pressed down. This is most easily managed with a small spoon, and one must not forget

No ant will willingly enter water, but they will pass down the little pathway, which should be provided for their use, drink, and carry moisture back to the nest for the use of the larvae.

Between your sheets of glass you now have a mass of soil and ants apparently in hopeless confusion. But leave the formicarium alone for a few hours, and then

forming a kind of very shallow tray, one opening, about an inch across, being left as the entrance. When the ants have been placed upon this tray, the upper sheet of glass is clamped into position with strong steel clips, and a wad of cotton is used to plug the entrance lest the ants should attempt to stray. In most cases, however, the insects will soon settle down



STUDYING BEES IN AN OBSERVATORY HIVE.

take a peep at it. You then see that the confusion, though very marked at first, is really anything but hopeless. The ants gradually settle down to the new conditions of life in which they find themselves. They excavate chambers and passages in the soil—a vast chamber for the queen, if you have been lucky enough to entrap her majesty, and many smaller ones for nurseries. They collect together all the scattered grubs and pupae they can find, sort them according to age, and begin at once to groom and caress them. They even contrive a special spot to be used exclusively as a cemetery, whither they convey the dead and hopelessly injured members of their colony.

In a very short space of time, in fact, confusion has given place to well ordered activity, and the ants go about their daily toil as though nothing out of the common had happened to them. And now the pleasure of your formicarium is manifest. The space between the upper and the lower glass is only just sufficient for an ant to walk about in comfort; so that in forming the galleries and chambers the ants are obliged to make use of the glass as roof and floor. Thus their

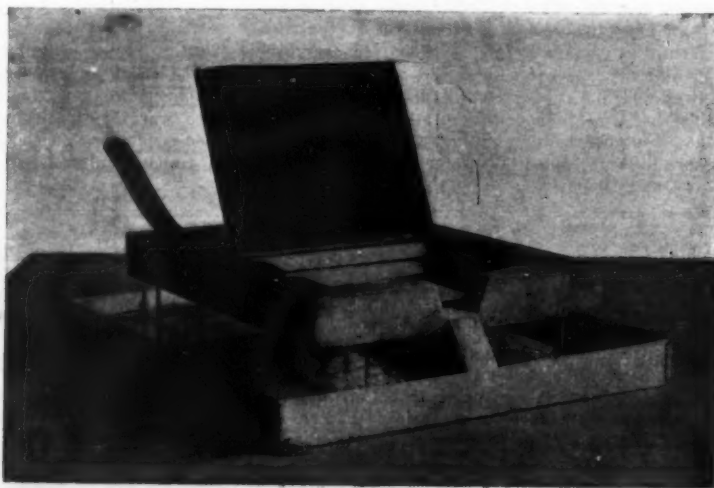
happily in their new quarters, affording their owner the means of much pleasurable observation.

But do not pet ants call for a great deal of care if they are to be kept healthy? The question is a natural one, and the answer will come to many readers as a surprise. For, despite what may be asserted to the contrary, pet ants require hardly any attention at all. Once a month, during the hot weather—perhaps once a fortnight when the atmosphere is very dry—the formicarium should be gently tilted, and about a tea-spoonful of water poured into the nest—more or less according to its size. Afterward a little honey should be inserted, and then the cotton plug may be replaced. With this small periodic supply of honey and water the ants will be perfectly contented and healthy; while in winter they need nothing at all, for the cold weather renders them dormant and inactive.

One thing, however, is essential for the well-being of these underground ants, and this is darkness. If left long in a strong light the little insects evince every sign of extreme distress, especially in regard to their young—the larvae and pupae—which they carry



GIVING THE ANTS THEIR FORTNIGHTLY SUPPLY OF HONEY.



A SIMPLE KIND OF FORMICARIUM.

ANTS AND BEES AS PETS

to put in a certain amount of fine earth for the ants to build with.

As soon as these operations have been effected, the top sheet of glass must be put into place, covered by the back of the printing frame, and all clamped down. The formicarium (as the ants' cage is termed) is now to be supported in a shallow pan of water, so that when the ants come abroad they may be kept within bounds.

doings are plainly visible from without, and by means of a tripod magnifying glass their every action may be watched with perfect ease.

In contriving one of the handy formicariums, the springs of the photo frame must always be weakened, otherwise the pressure will prove too great and crack the glass. Much larger homes for ants may be made on the same principle, as shown herewith. In such cases it is best to cement the narrow slips of glass upon the large sheet which is to form the floor, thus

about from one side of the formicarium to the other in the hope of finding shelter for them. Therefore, when observing your ants do so as much as possible in a subdued light; and when not observing them be sure that the glass top of their home is covered. By this means you will add materially to the happiness of your ants, and they will repay you by thriving from day to day. Ants carefully tended according to the simple directions which have been given will live for years in captivity.

* From *American Homes and Gardens*. Published by Mann & Co.

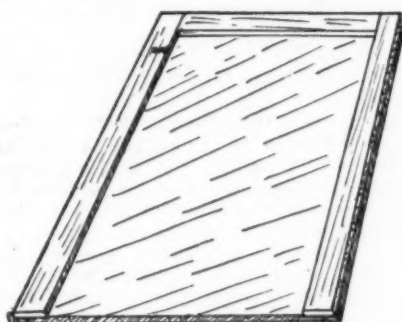
Pet bees are, if possible, more interesting than pet ants, while in keeping them one experiences the novelty of enjoying honey which one has actually seen being made. Bees may safely be kept in any ordinary room, upon a side table, provided they are housed in a small observation hive. Briefly, this is a diminutive hive, made to carry one, two or three of the regulation "frames," but with glass sides in place of the usual wooden ones. Darkness for the inmates is secured by



ARTIFICIAL COMB MADE BY MACHINERY.

means of blinds or screens when the bees are not actually under observation. But as bees must have liberty throughout the summer, and as it would be highly unpleasant to have them streaming through one's door and windows at all hours of the day, the entrance of their home is connected by a tube with a one-inch hole in the nearest window sash. Through this tube the bees go merrily to their labors among the flowers; through it they return laden with honey. So that by means of these observation hives one may witness the storing of honey, and all the intricate details of bee life, and yet never be stung, or in any way inconvenienced by the going and coming of the insects.

It will be quite possible for the reader, should he have a smattering of carpentering at his disposal, to construct an observation hive for himself, converting any old wooden box to this end. The necessary measurements of the regulation frames to be accommodated, etc., can be obtained from any handbook on bee keeping, while the same source will supply information on the subject of installing a swarm of bees in its new home. But unless the would-be student of insect life



HOW THE NARROW STRIPS OF GLASS ARE ARRANGED UPON THE LOWER OR "FLOOR" GLASS IN IMPROMPTU FORMICARIUM.

has already had some experience of practical bee-keeping on a large scale, he will do well to enlist the services of an established apiarist when he is ready to put bees into his observation hive—otherwise he may experience difficulties and dangers greater than he bargained for. Once the bees are established, however, they will give no further trouble, while they will prove a constant source of pleasure, and may become actually profitable. Even in big cities, where bees are restricted to the limited number of flowers to be found in window boxes, back gardens, and the ornamental beds of parks and open spaces, the insects contrive to

collect honey in considerable quantity. This the writer can vouch for from actual experience. Then, too, the owner of an observation hive may try all manner of experiments on his bees, such as marking a bee with a spot of paint, and recording the number of hours which it devotes to labor each day. He may see, also, the cute way in which his pets accept a rank of artificial comb, stamped by machinery, and thus save themselves the weary process of wax making. To the writer this acceptance of aid offered by mankind appears to be among the most remarkable of all bee traits.

It may be said that it is quite possible to keep wasps in a roomy observation hive. They are fascinating pets, and afford infinite diversion by their elaborate paper-making schemes, by means of which the nest is enlarged and sheltered. But it is a very difficult matter to transfer a colony of wasps to a hive; and the reader will be well advised to refrain from attempting the task, at least until he has had some experience with bees, which insects are less fierce in disposition, and have less powerful stings.

While it is quite true one may obtain a substantial



THE OBSERVATORY HIVE WITH DOOR OPEN.

amount of honey from an observation hive, it is hardly to be expected that anyone will maintain these useful insects in this way for that purpose chiefly or alone. The honey one may take from these hives is, in fact, apt to be but comparatively small in amount, and quite a secondary product of the whole business. The merit of the observation hive is its exceeding interest and its wonderful mystery. Here there is no limit, and one may watch and study the busy little creatures for hours without really finding out what they are doing, or what is accomplished by their ceaseless movements. But the interest they excite is always present. There is always something going on. There is very much going on, and going on all the time. It is the mystery of insect life that excites one's interest in this wonderful activity, with the added interest that you know that a definite insect product is being manufactured immediately under your eyes, a product, perchance, for your own delectation.

I have written of these two curious forms of insect life, and told, in a very brief way, how they can be maintained on the library table or at any convenient point within the house, because the love of animals seems deeply ingrained in the human heart. And I submit that no animals can be kept with less trouble than ants and bees. If, at first blush, it may appear a bit strange to look upon these curious creatures as pets, the notion falls away immediately, I am sure, when the ways of keeping them, and the easy means of observation that may be provided are made known. One may not, indeed, be prepared to take the ants and bees out of their strange homes and fondle them, but one can always watch them, always study them, always learn something from them.

No other form of animal life may be kept within the house so neatly and so readily. Practically no care is required. The keeping places or houses are to all intents and purposes hermetically sealed, and one has but to roll up a curtain or lift a cloth to have all the mysteries of the insect's private life displayed for all who may wish to view them. And this is something accomplished. Many interesting forms of animal life



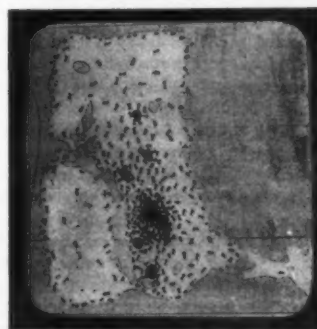
COMB MADE BY BEES.

can not be maintained within the house because the creatures are unpleasant or their care involves too many difficulties. But the ants and bees will flourish everywhere, and may everywhere be objects of interest.

ARTIFICIAL CYCLOPSISM.

CYCLOPEAN monsters have long been known, in the human and other species of mammals. Numerous cases have been discovered and carefully studied, but until recently the artificial production of such monsters was not believed to be possible, because it was supposed that the malformation was caused by some abnormality in the ovum, due to an inherited tendency.

Development, however, does not depend solely upon the ovum, but is influenced by external conditions. Ordinarily, the interaction of these two factors results in the development of normal forms, but the influence of an abnormal environment may either arrest development entirely or produce aberrant forms.



WORKERS SURROUNDING THE QUEEN IN THE ANTS' NEST.

Most monsters, or examples of abnormal development, in fact, are produced by external influences, either chemical or mechanical. There are certain classical aberrant forms, which are always produced by definite chemical agents. Examples are Herbst's abnormal sea urchin larva and Morgan's abnormal frog embryo, both of which are produced by the action of lithium.

Quite recently C. R. Stockard has produced a Cyclopean larval form of a marine fish (*Fundulus heteroclitus*) by the agency of magnesium. This is the first Cyclopean monster yet observed among fishes and also



THE ANTS' NEST. THE PLUG OF COTTON SEALS THE ONLY ENTRANCE.



ADMINISTERING MOISTURE TO THE ANTS.



EXAMINING ANTS IN THE FORMICARIUM.

ANTS AND BEES AS PETS.

The first vertebrate Cyclopean monster produced artificially by chemical means.

To obtain Cyclopean fry of *Fundulus* it is only necessary to place the eggs in sea water containing an excess of magnesium. The best results are obtained by adding to 41 volumes of sea water 19 volumes of a molecular solution of magnesium chloride ($MgCl_2$) in distilled water. Fifty per cent of the eggs immersed in this mixture develop into Cyclopean fry, the appearance of which is very characteristic and quite similar to that of human Cyclopean monsters. The single eye, which may be simple or double in structure, is situated in the median line of the

face, the nostrils are borne on a trunk directed downward and the mouth is ventral. The one-eyed fry hatch almost as soon as the normal larvae. They swim perfectly well, avoiding obstacles with a skill which proves that their visual powers are not sensibly impaired. They live as long as normal embryos subjected to the same conditions; that is to say, about ten days, or until the nutriment stored in the vitelline sack is exhausted.

Stockard has studied 275 Cyclopean *Fundulus* larvae. Various degrees of abnormality were found among these, but in no case was the Cyclopism due to fusion of two originally separate eyes. According

to Stockard, the magnesium exerts an anæsthetic influence. It inhibits muscular activity and either completely arrests the development of the optical vesicles, producing total blindness, or deprives them of the energy required to effect the normal separation, producing Cyclopism. It is a curious fact that the other organs, the brain in particular, develop in a normal manner.

The results of these experiments have suggested to Stockard the hypothesis that the production of all Cyclopean monsters, in the human and other mammal species, is due to an excess of magnesium salts in the mother's blood or in the amniotic liquor.

STUDIES OF ELECTRICITY AND MATTER.*

A RESUMÉ OF RECENT INVESTIGATION.

BY SIR J. J. THOMSON.

A STRIKING discovery like that of the Roentgen rays acts much like the discovery of gold in a sparsely populated country; it attracts workers who come in the first place for the gold, but who may find that the country has other products, other charms, perhaps even more valuable than the gold itself. The country in which the gold was discovered in the case of the Roentgen rays was the department of physics dealing with the discharge of electricity through gases, a subject which, almost from the beginning of electrical science, had attracted a few enthusiastic workers, who felt convinced that the key to unlock the secret of electricity was to be found in a vacuum tube. Roentgen, in 1895, showed that when electricity passed through such a tube, the tube emitted rays which could pass through bodies opaque to ordinary light; which could, for example, pass through the flesh of the body and throw a shadow of the bones on a suitable screen. The fascination of this discovery attracted many workers to the subject of the discharge of electricity through gases, and led to great improvements in the instruments used in this type of research. It is not, however, to the power of probing dark places, important though this is, that the influence of Roentgen rays on the progress of science has mainly been due; it is rather because these rays make gases, and, indeed, solids and liquids, through which they pass conductors of electricity. It is true that before the discovery of these rays other methods of making gases conductors were known, but none of these was so convenient for the purposes of accurate measurement.

The study of gases exposed to Roentgen rays has revealed in such gases the presence of particles charged with electricity; some of these particles are charged with positive, others with negative electricity.

The properties of these particles have been investigated; we know the charge they carry, the speed with which they move under an electric force, the rate at which the oppositely charged ones recombine, and these investigations have thrown a new light, not only on electricity, but also on the structure of matter.

We know from these investigations that electricity, like matter, is molecular in structure, that just as a quantity of hydrogen is a collection of an immense number of small particles called molecules, so a charge of electricity is made up of a great number of small charges, each of a perfectly definite and known amount.

Helmholtz said in 1880 that in his opinion the evidence in favor of the molecular constitution of electricity was even stronger than that in favor of the molecular constitution of matter. How much stronger is that evidence now, when we have measured the charge on the unit and found it to be the same from whatever source the electricity is obtained. Nay, further, the molecular theory of matter is indebted to the molecular theory of electricity for the most accurate determination of its fundamental quantity, the number of molecules in any given quantity of an elementary substance.

The great advantage of the electrical methods for the study of the properties of matter is due to the fact that whenever a particle is electrified it is very easily identified, whereas an uncharged molecule is most elusive; and it is only when these are present in immense numbers that we are able to detect them. A very simple calculation will illustrate the difference in our power of detecting electrified and unelectrified molecules. The smallest quantity of unelectrified matter ever detected is probably that of neon, one of the inert gases of the atmosphere. Prof. Strutt has shown that the amount of neon in 1/20 of a cubic centimeter of the air at ordinary pressures can be detected by the spectroscope; Sir William Ramsay estimates that the neon in the

air only amounts to one part of neon, in 100,000 parts of air, so that the neon in 1/20 of a cubic centimeter of air would only occupy at atmospheric pressure a volume of half a millionth of a cubic centimeter. When stated in this form the quantity seems exceedingly small, but in this small volume there are about ten million million molecules. Now the population of the earth is estimated at about fifteen hundred millions, so that the smallest number of molecules of neon we can identify is about 7,000 times the population of the earth. In other words, if we had no better test for the existence of a man than we have for that of an unelectrified molecule we should come to the conclusion that the earth is uninhabited. Contrast this with our power of detecting electrified molecules. We can by the electrical method, even better by the cloud method of C. T. R. Wilson, detect the presence of three or four charged particles in a cubic centimeter. Rutherford has shown that we can detect the presence of a single particle. Now the particle is a charged atom of helium; if this atom had been uncharged we should have required more than a million million of them, instead of one, before we should have been able to detect them.

We may, I think, conclude, since electrified particles can be studied with so much greater ease than unelectrified ones, that we shall obtain a knowledge of the ultimate structure of electricity before we arrive at a corresponding degree of certainty with regard to the structure of matter.

We have already made considerable progress in the task of discovering what the structure of electricity is. We have known for some time that of one kind of electricity—the negative—and a very interesting one it is. We know that negative electricity is made up of units all of which are of the same kind; that these units are exceedingly small compared with even the smallest atom, for the mass of the unit is only 1/1700 part of the mass of an atom of hydrogen; that its radius is only 10^{-13} centimeter, and that these units, "corpuscles" as they have been called, can be obtained from all substances. The size of these corpuscles is on an altogether different scale from that of atoms; the volume of a corpuscle bears to that of the atom about the same relation as that of a speck of dust to the volume of this room. Under suitable conditions they move at enormous speeds which approach in some instances the velocity of light.

The discovery of these corpuscles is an interesting example of the way Nature responds to the demands made upon her by mathematicians. Some years before the discovery of corpuscles it had been shown by a mathematical investigation that the mass of a body must be increased by a charge of electricity. This increase, however, is greater for small bodies than for large ones, and even bodies as small as atoms are hopelessly too large to show any appreciable effect; thus the result seemed entirely academic. After a time corpuscles were discovered, and these are so much smaller than the atom that the increase in mass due to the charge becomes not merely appreciable, but so great that, as the experiments of Kaufmann and Bucherer have shown, the whole of the mass of the corpuscle arises from its charge.

We know a great deal about negative electricity; what do we know about positive electricity? Is positive electricity molecular in structure? Is it made up into units, each unit carrying a charge equal in magnitude though opposite in sign to that carried by a corpuscle? Does, or does not, this unit differ, in size and physical properties, very widely from the corpuscle? We know that by suitable processes we can get corpuscles out of any kind of matter, and that the corpuscles will be the same from whatever source they may be derived. Is a similar thing true for positive electric-

ity? Can we get, for example, a positive unit from oxygen of the same kind as that we get from hydrogen?

For my own part, I think the evidence is in favor of the view that we can, although the nature of the unit of positive electricity makes the proof much more difficult than for the negative unit.

In the first place we find that the positive particles—"canalstrahlen"—is their technical name—discovered by Dr. Goldstein, which are found when an electric discharge passes through a highly rarefied gas, are, when the pressure is very low, the same, whatever may have been the gas in the vessel to begin with. If we pump out the gas until the pressure is too low to allow the discharge to pass, and then introduce a small quantity of gas and restart the discharge, the positive particles are the same whatever kind of gas may have been introduced.

Some experiments made lately by Wellisch, in the Cavendish Laboratory, strongly support the view that there is a definite unit of positive electricity independent of the gas from which it is derived; these experiments were on the velocity with which positive particles move through mixed gases. If we have a mixture of methyl-iodide and hydrogen exposed to Roentgen rays, the effect of the rays on the methyl-iodide is so much greater than on the hydrogen that, even when the mixture contains only a small percentage of methyl-iodide, practically all the electricity comes from this gas, and not from the hydrogen.

Now if the positive particles were merely the residue left when a corpuscle had been abstracted from the methyl-iodide, these particles would have the dimensions of a molecule of methyl-iodide; this is very large and heavy, and would therefore move more slowly through the hydrogen molecules than the positive particles derived from hydrogen itself, which would, on this view, be of the size and weight of the light hydrogen molecules. Wellisch found that the velocities of both the positive and negative particles through the mixture were the same as the velocities through pure hydrogen, although in the one case the ions had originated from methyl-iodide and in the other from hydrogen; a similar result was obtained when carbon tetrachloride, or mercury methyl, was used instead of methyl-iodide. These and similar results lead to the conclusion that the atoms of the different chemical elements contain definite units of positive as well as of negative electricity, and that the positive electricity, like the negative, is molecular in structure.

The investigations made on the unit of positive electricity show that it is of quite a different kind from the unit of negative. The mass of the negative unit is exceedingly small compared with any atom. The only positive units that up to the present have been detected are quite comparable in mass with the mass of an atom of hydrogen; in fact they seem equal to it. This makes it more difficult to be certain that the unit of positive electricity has been isolated, for we have to be on our guard against its being a much smaller body attached to the hydrogen atoms which happen to be present in the vessel. If the positive units have a much greater mass than the negative ones, they ought not to be so easily deflected by magnetic forces when moving at equal speeds; and in general the insensibility of the positive particles to the influence of a magnet is very marked; though there are cases when the positive particles are much more readily deflected, and these have been interpreted as proving the existence of positive units comparable in mass with the negative ones. I have found, however, that in these cases the positive particles are moving very slowly, and that the ease with which they are deflected is due to the smallness of the velocity and not to that of the mass. It should, however, be noted that M. Jean Becquerel has observed in the absorption spectra of some min-

* Abstracted from the Presidential address to the British Association for the Advancement of Science.

erals, and Prof. Wood in the rotation of the plane of polarization by sodium vapor, effects which could be explained by the presence in the substances of positive units comparable in mass with corpuscles. This, however, is not the only explanation which can be given of these effects, and at present the smallest positive electrified particles of which we have direct experimental evidence have masses comparable with that of an atom of hydrogen.

A knowledge of the mass and size of the two units of electricity, the positive and the negative, would give us the material for constructing what may be called a molecular theory of electricity, and would be a starting-point for a theory of the structure of matter; for the most natural view to take, as a provisional hypothesis, is that matter is just a collection of positive and negative units of electricity, and that the forces which hold atoms and molecules together, the properties which differentiate one kind of matter from another, all have their origin in the electrical forces exerted by positive and negative units of electricity, grouped together in different ways in the atoms of the different elements.

As it would seem that the units of positive and negative electricity are of very different sizes, we must regard matter as a mixture containing systems of very different types, one type corresponding to the small corpuscles, the other to the large positive unit.

Since the energy associated with a given charge is greater the smaller the body on which the charge is concentrated, the energy stored up in the negative corpuscles will be far greater than that stored up by the positive. The amount of energy which is stored up in ordinary matter in the form of the electrostatic potential energy of its corpuscles is, I think, not generally realized. All substances give out corpuscles, so that we may assume that each atom of a substance contains at least one corpuscle. From the size and the charge on the corpuscle, both of which are known, we find that each corpuscle has 8×10^{-7} ergs of energy; this is on the supposition that the usual expressions for the energy of a charged body hold when, as in the case of a corpuscle, the charge is reduced to one unit. Now in one gramme of hydrogen there are about 6×10^{23} atoms, so if there is only one corpuscle in each atom the energy due to the corpuscles in a gramme of hydrogen would be 48×10^{16} ergs, or 11×10^9 calories. This is more than seven times the heat developed by one gramme of radium, or than that developed by the burning of five tons of coal. Thus we see that even ordinary matter contains enormous stores of energy; this energy is fortunately kept fast bound by the corpuscles; if at any time an appreciable fraction were to get free the earth would explode and become a gaseous nebula.

The matter of which I have been speaking so far is the material which builds up the earth, the sun, and the stars, the matter studied by the chemist, and which he can represent by a formula; this matter occupies, however, but an insignificant fraction of the universe; it forms but minute islands in the great ocean of the ether, the substance with which the whole universe is filled.

The ether is not a fantastic creation of the speculative philosopher; it is as essential to us as the air we breathe. For we must remember that we on this earth are not living on our own resources; we are dependent from minute to minute upon what we are getting from the sun, and the gifts of the sun are conveyed to us by the ether. It is to the sun that we owe not merely night and day, springtime and harvest, but it is the energy of the sun, stored up in coal, in waterfalls, in food, that practically does all the work of the world.

How great is the supply the sun lavishes upon us becomes clear when we consider that the heat received by the earth under a high sun and a clear sky is equivalent, according to the measurements of Langley, to about 7,000 horse-power per acre. Though our engineers have not yet discovered how to utilize this enormous supply of power, they will, I have not the slightest doubt, ultimately succeed in doing so; and when coal is exhausted and our water-power inadequate, it may be that this is the source from which we shall derive our energy necessary for the world's work. When that comes about, our centers of industrial activity may perhaps be transferred to the burning deserts of the Sahara, and the value of land determined by its suitability for the reception of traps to catch sunbeams.

This energy, in the interval between its departure from the sun and its arrival at the earth, must be in the space between them. Thus this space must contain something which, like ordinary matter, can store up energy, which can carry at an enormous pace the energy associated with light and heat, and which can, in addition, exert the enormous stresses necessary to keep the earth circling round the sun and the moon round the earth.

The study of this all-pervading substance is perhaps the most fascinating and important duty of the physicist.

On the electromagnetic theory of light, now universally accepted, the energy streaming to the earth trav-

els through the ether in electric waves; thus practically the whole of the energy at our disposal has at one time or another been electrical energy. The ether must, then, be the seat of electrical and magnetic forces. We know, thanks to the genius of Clerk Maxwell, the founder and inspirer of modern electrical theory, the equations which express the relation between these forces, and although for some purposes these are all we require, yet they do not tell us very much about the nature of the ether.

The interest inspired by equations, too, in some minds is apt to be somewhat Platonic; and something more grossly mechanical—a model, for example, is felt by many to be more suggestive and manageable, and for them a more powerful instrument of research, than a purely analytical theory.

Is the ether dense or rare? Has it a structure? Is it at rest or in motion? are some of the questions which force themselves upon us.

Let us consider some of the facts known about the ether. When light falls on a body and is absorbed by it, the body is pushed forward in the direction in which the light is traveling, and if the body is free to move it is set in motion by the light. Now it is a fundamental principle of dynamics that when a body is set moving in a certain direction, or, to use the language of dynamics, acquires momentum in that direction, some other mass must lose the same amount of momentum; in other words, the amount of momentum in the universe is constant. Thus when the body is pushed forward by the light some other system must have lost the momentum the body acquires, and the only other system available is the wave of light falling on the body; hence we conclude that there must have been momentum in the waves in the direction in which it is traveling. Momentum, however, implies mass in motion. We conclude, then, that in the ether through which the wave is moving there is mass moving with the velocity of light. The experiments made on the pressure due to light enable us to calculate this mass, and we find that in a cubic kilometer of ether carrying light as intense as sunlight is at the surface of the earth, the mass moving is only about one-fifty-millionth of a milligramme. We must be careful not to confuse this with the mass of a cubic kilometer of ether; it is only the mass moved when the light passes through it; the vast majority of the ether is left undisturbed by the light. Now, on the electromagnetic theory of light, a wave of light may be regarded as made up of groups of lines of electric force moving with the velocity of light; and if we take this point of view we can prove that the mass of ether per cubic centimeter carried along is proportional to the energy possessed by these lines of electric force per cubic centimeter, divided by the square of the velocity of light. But though lines of electric force carry some of the ether along with them as they move, the amount so carried, even in the strongest electric fields we can produce, is but a minute fraction of the ether in their neighborhood.

This is proved by an experiment made by Sir Oliver Lodge in which light was made to travel through an electric field in rapid motion. If the electric field had carried the whole of the ether with it, the velocity of the light would have been increased by the velocity of the electric field. As a matter of fact no increase whatever could be detected, though it would have been registered if it had amounted to one-thousandth part of that of the field.

The ether carried along by a wave of light must be an exceedingly small part of the volume through which the wave is spread. Parts of this volume are in motion, but by far the greater part is at rest. Thus in the wave front there cannot be uniformity; at some parts the ether is moving, at others it is at rest—in other words, the wave front must be more analogous to bright specks on a dark ground than to a uniformly illuminated surface.

The place where the density of the ether carried along by an electric field rises to its highest value is close to a corpuscle, for round the corpuscles are by far the strongest electric fields of which we have any knowledge. We know the mass of the corpuscle, we know from Kaufmann's experiments that this arises entirely from the electric charge, and is therefore due to the ether carried along with the corpuscle by the lines of force attached to it.

A simple calculation shows that one-half of this mass is contained in a volume seven times that of a corpuscle. Since we know the volume of the corpuscle as well as the mass, we can calculate the density of the ether attached to the corpuscle; doing so, we find it amounts to the prodigious value of about 5×10^{10} , or about 2,000 million times that of lead. Sir Oliver Lodge, by somewhat different considerations, has arrived at a value of the same order of magnitude.

Thus around the corpuscle ether must have an extravagant density: whether the density is as great as this in other places depends upon whether the ether is compressible or not. If it is compressible, then it may be condensed round the corpuscles, and there have an abnormally great density; if it is not com-

pressible, then the density in free space cannot be less than the number I have just mentioned.

With respect to this point we must remember that the forces acting on the ether close to the corpuscle are prodigious. If the ether were, for example, an ideal gas whose density increased in proportion to the pressure, however great the pressure might be, then if, when exposed to the pressures which exist in some directions close to the corpuscle, it had the density stated above, its density under atmospheric pressure would only be about 8×10^{-10} , or a cubic kilometer would have been a mass less than a gramme; so that instead of being almost incomparably denser than lead, it would be almost incomparably rarer than the lightest gas.

I do not know at present of any effect which would enable us to determine whether ether is compressible or not. And although at first sight the idea that we are immersed in a medium almost infinitely denser than lead might seem inconceivable, it is not so if we remember that in all probability matter is composed mainly of holes. We may, in fact, regard matter as possessing a bird-cage kind of structure in which the volume of the ether disturbed by the wires when the structure is moved is infinitesimal in comparison with the volume inclosed by them. If we do this, no difficulty arises from the great density of the ether; all we have to do is to increase the distance between the wires in proportion as we increase the density of the ether.

Let us now consider how much ether is carried along by ordinary matter, and what effects this might be expected to produce.

The simplest electrical system we know, an electrified sphere, has attached to it a mass of ether proportional to its potential energy, and such that if the mass were to move with the velocity of light its kinetic energy would equal the electrostatic potential energy of the particle. This result can be extended to any electrified system, and it can be shown that such a system binds a mass of the ether proportional to its potential energy. Thus a part of the mass of any system is proportional to the potential energy of the system.

The question now arises, Does this part of the mass add anything to the weight of the body? If the ether were not subject to gravitational attraction it certainly would not; and even if the ether were ponderable, we might expect that as the mass is swimming in a sea of ether it would not increase the weight of the body to which it is attached. But if it does not, then a body with a large amount of potential energy may have an appreciable amount of its mass in a form which does not increase its weight, and thus the weight of a given mass of it may be less than that of an equal mass of some substance with a smaller amount of potential energy. Thus the weights of equal masses of these substances would be different. Now, experiments with pendulums, as Newton pointed out, enable us to determine with great accuracy the weights of equal masses of different substances. Newton himself made experiments of this kind, and found that the weights of equal masses were the same for all the material he tried. Bessel, in 1830, made some experiments on this subject which are still the most accurate we possess, and he showed that the weights of equal masses of lead, silver, iron, brass did not differ by as much as one part in 60,000.

The substances tried by Newton and Bessel did not, however, include any of those substances which possess the marvelous power of radio-activity; the discovery of these came much later, and is one of the most striking achievements of modern physics.

These radio-active substances are constantly giving out large quantities of heat, presumably at the expense of their potential energy; thus when these substances reach their final non-radio-active state their potential energy must be less than when they were radio-active. Prof. Rutherford's measurements show that the energy emitted by one gramme of radium in the course of its degradation to non-radio-active forms is equal to the kinetic energy of a mass of $1/13$ th of a milligramme moving with the velocity of light.

This energy, according to the rule I have stated, corresponds to a mass of $1/13$ th of a milligramme of the ether, and thus a gramme of radium in its radio-active state must have at least $1/13$ th of a milligramme more of ether attached to it than when it has been degraded into the non-radio-active forms. Thus if this ether does not increase the weight of the radium, the ratio of mass to weight for radium would be greater by about one part in 13,000 than for its non-radio-active products.

(To be concluded.)

Caps (Amorces).—Stick together two small pieces of tissue paper between which a little fulminating mixture (chlorate of potash and red phosphorus, mixed with mucilage) has been placed. They detonate by concussion or jolt, with a fairly loud report and are used as ammunition for toy pistols, also as igniters.

THE AUTOMATIC TELEPHONE.

THE GIRL-LESS CENTRAL OFFICE.

BY SNOWDEN B. REDFIELD.

It is a matter of but a few years when a person desiring to call another on the telephone will not only make all his own electric connections for talking, but will deposit his money in an automatic meter, talk as long as he likes and then have his change automatically handed back to him.

All those who have occasion to use the telephone, and this classification takes in practically every inhabitant of every civilized country in the world, have often had occasion to wish that the personality of the telephone central could be eliminated. It is said that from this very wish the idea of the automatic telephone central had its origin, for one of the early inventors along these lines, Almon B. Strowger, was spurred on in the field of automatic telephony very largely by his exasperation over the annoying performances of the "hello girls" in his own town.

There have been rumors of automatic telephone centrals for several years, but the idea in the mind of the general public is that these automatic machines are applicable only to very limited service, and that it would be an impossibility to extend them for use in a city. This idea, however, is entirely erroneous, for the day is doubtless approaching when all telephone central work will be done by automatic devices. As these machines are now being put out by their manufacturers, there is no reason why there should be any limitation at all to the extent of the service.

One company is manufacturing and installing an ingenious system which has the characteristic of

which the arms *F* are made to travel by means of the motor magnet *MM* so as to connect to the proper telephone lines. The motor magnet operates upon the ratchet wheel to push the arms *F* around one step for each vibration of the armature of *MM*. Ten vibrations would move the arms *F* 10 steps, 15 vibrations would move the arms 15 steps. *R* is the release magnet which, when the receiver is finally hung up after the conversation is finished, allows the arms *F* to swing back to the extreme left-hand or disconnected position. *G* is a relay which furnishes current to

of switches, which are thrown one after the other by impulses which are sent over the telephone line by means of the calling device shown in Fig. 1. Fig. 3 is a closer view of the calling device, which the manufacturers term their "sub-station selector." This device is nothing more nor less than a clock-work mechanism, designed to operate an electric commutator, which is shown in the right-hand view, Fig. 3. One revolution of the commutator sends one current impulse over the line; two rotations send two impulses, and so on. By rotating the mechanism any given dis-



FIG. 1.—DESK FORM, WITH CALLING DEVICE.

being a two-wire system as opposed to the old three-wire system, used for both manual and automatic operation. The system also uses central energy; that is, the electric current for talking and for ringing and for the operation of the automatic central devices is furnished from the central office itself. The whole operation of switching, to connect any one subscriber to any other subscriber, is entirely automatic without any manual intervention in the central office. In this way a subscriber puts in his own calls, and his getting of the right number depends only upon himself. When his number has once been obtained there is no possibility of interruption from the outside, and also there is no possibility of his conversation being overheard.

THE AUTOMATIC SWITCHES.

The telephone itself, as is well known, is about the most complicated device at present in use, and when the central office is made automatic an explanation of its operation to be at all understandable to those not directly educated in telephone work, must necessarily deal only with the general principles. The transmitting and receiving devices are of the same general design as those used on the ordinary manually-operated telephones. The only difference in appearance is in the calling device, which, as seen in Fig. 1, is very inconspicuous and does not in any way detract from the simple appearance of the telephone itself.

Fig. 2 illustrates one of the central-office switches, known as the "connector." In this figure *E* will be seen to represent a bank of 50 groups of contacts over

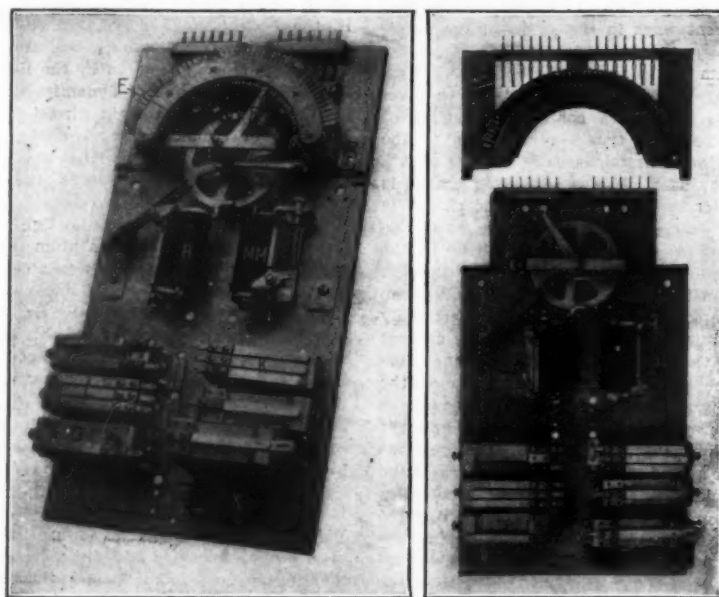


FIG. 2.—CONNECTOR, OR FINAL CENTRAL OFFICE SWITCH.

operate the motor magnet *MM*. The relay *G* takes only the small current flowing in the telephone line itself, when the receiver is removed, but by its operation a current heavy enough to positively operate the motor magnet is passed through the coils of the latter.

In all of these automatic switches there is used what is termed a "slow magnet," at various steps in the operation. These slow magnets resemble an ordinary electromagnet composed of a soft-iron core covered with a coil of insulated wire, but in addition there is a copper sleeve placed over the soft-iron core and under the wire winding. The effect of this copper sleeve is to prevent the magnetism in the soft-iron core from being lost immediately after the current is cut off from the coil. In this way if the slow magnet is energized by a current and rapid breaks and makes are produced in this current, the magnetism does not have time enough to become inactive during the interval that the current is broken. The

tance, a predetermined number of impulses can be sent over the line in succession.

The call numbers are made up of letters and numbers. For instance, let a subscriber's number be DC12, the handle on the front of the calling device is turned so that the pointer comes opposite the letter *D*. The handle is pressed down, which inserts a pin in one of the holes around the circumference of the calling device. The lever is then moved around to the right until it strikes against the stop at the bottom. It is then released and allowed to turn back again by its own spring mechanism. Next, the pointer is brought opposite the letter *C*, the lever is again pressed down, inserting the pin, and the device rotated and allowed again to spring back to its normal position. After this the pointer is placed opposite the numeral 12, and the device again allowed to spring back. Each one of these processes of springing back has sent over the line by means of the commutator,

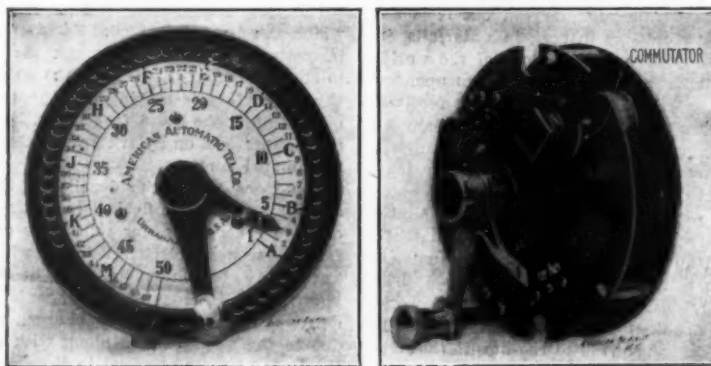


FIG. 3.—CALLING DEVICE, WITH AND WITHOUT FRONT PLATE.

THE AUTOMATIC TELEPHONE CENTRAL.

effect of this is to keep the magnet practically constantly magnetized, holding its armature in place during the time that a more or less rapidly interrupted current is being passed through its coils. The use of this device will be seen in the later explanation.

SENDING IN THE CALL.

In order to connect any one subscriber to any other, the subscribers are divided into groups of 500. These groups of 500 are brought down to groups of 50, and finally down to the single subscriber. The various groups and individuals are reached by a succession

a number of impulses corresponding exactly to the letter and the number; the letter *D* corresponding to 15 impulses, the letter *C* corresponding to 10 impulses, and the numeral 12 corresponding to 12 more impulses. The first set of impulses moves one switch, the next set moves a succeeding switch, and a final set of impulses moves the final switch. After this the calling device is again rotated for a short distance, which causes a ringing relay (*K*, Fig. 2) to be thrown into operation, thus ringing the bell on the telephone of the subscriber being called.

By these successive sets of impulses any number may be called, as it is not at all necessary to make the number of holes, or revolutions of the commutator, more than a mere fraction of the number of the subscriber. As a matter of fact, the first set of impulses connects with a group of 500 subscribers, the second limits this to 50, and the third set of impulses finally locates the individual. In this way it is seen that so far as the matter of calling is concerned, there

these are passed on to the one of 10 connector switches in the group *D'* which is connected to the contact upon which the switch in second selector *C'* came to rest. In the diagram this is shown to be the second upper connector switch in the group *D'*, and this last set of impulses moves the switch in this connector around to the contact corresponding to the number of impulses in the last series sent out by the calling subscriber. This contact would correspond to the line

connect him to any connector in any one of the 10 groups of 10 connectors each, and as each connector leads directly to 50 subscribers, the 10 groups of 10 connectors each make up the total number of 5,000 subscribers illustrated by the diagram. This principle may be extended as far as desired for any one central station, and by means of trunk lines from one central to another, just as with the manual system, these various centrals may be connected together and a telephone system of practically unlimited size may be thus made entirely automatic in every way.

SEVERAL TALKING AT ONCE.

By putting in 100 finders instead of one, all properly connected to corresponding first selector switches, and correctly multiplied together, it will be understood that any one of 5,000 subscribers can talk to any other one of the same 5,000; that is, only one person talking at a time. As it is, of course, necessary that more than one person in 5,000 should talk at once in such a telephone system, it is necessary to make provision for this.

As a matter of fact, instead of there being one finder to every 50 calling subscribers there are six finders for every 50 subscribers, and there are six first selectors corresponding to each six finders; that is, one first selector for each finder. Instead of there being only 10 contacts on the first selectors and the second selectors there are 10 groups of five contacts; that is, 50 contacts in all. These contacts are so multiplied together that in case the turning of the switch, say on the first selector, should bring it to a line leading to a busy second selector, its coming to rest for an instant allows one of the little slow magnets to operate, throwing in a vibrating relay on the first selector which sends a further set of impulses into the motor magnet in this same first selector, causing it to rotate until it reaches one of the multiple non-busy lines leading into the same group of second selectors desired.

Instead of there being but 10 second selectors for each first selector, there are 40 second selectors for each first one, these being in groups and multiplied together on the groups of contacts in the bank of 50 contacts on each first selector switch. Thus, in case a subscriber tries to call in on a busy selector switch on the way to the final connector switch, which he desires to reach, which latter we will assume is not busy, the machine itself automatically hunts out a contact in the selector which is not busy and passes on the call to the next switch which is also not busy, and provided the final subscriber desired is not using his 'phone at that time, the ultimate connection is attained.

This automatic hunting out of non-busy wires is one of the most interesting and essential features of an automatic calling system. It necessarily introduces

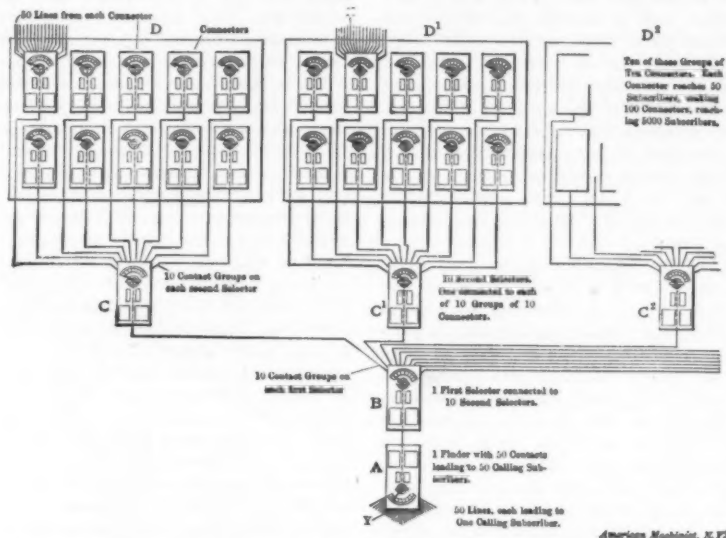


FIG. 4.—DIAGRAMMATIC LAYOUT OF AUTOMATIC SYSTEM FOR 5,000 SUBSCRIBERS.

is absolutely no limit to the size of the calling number, nor the number of subscribers on the line that may be called with an automatic device such as this.

In order to explain the system it will be best to remove as much as possible all elements of complication by limiting ourselves to the case of one of 50 subscribers talking to any one of 5,000 subscribers. By limiting it to but one person talking at a time, the matter is made much clearer and the elements of multiplication are entirely removed, while a reasonably clear idea of its general operation is obtained.

GETTING THE CONNECTION.

Fig. 4 is a diagram of an automatic system which will allow any one of 50 subscribers to talk to any one of 5,000 on the system. In this figure, A is termed the "finder switch," B is termed the "first selector," C the "second selector," and D groups of 10 "connector switches." All of these switches are very much alike; in fact, the parts are nearly all duplicates, although differently arranged and differently connected in the various switches, and they all bear the general appearance of Fig. 2. The finder may be described as a selector or connector, operated in the opposite direction.

In Fig. 4 let it be assumed that the subscriber on line Y wishes to talk to the subscriber on the line X in the second group *D'* at the top of the figure. There are 50 separate telephone lines coming into finder A, and when the subscriber on line Y removes his receiver, the connections to the central office and the finder A are such that what is known as a "vibrating relay," which operates somewhat on the principle of an electric bell, and which is part of the finder itself, furnishes an intermittent current to its motor magnet *MM*, as shown in Fig. 2, causing the arms *F* to rotate, passing over the contacts in the bank *E* until a point is found where no ground connection is established. This will be the line Y, from which the receiver has been removed. The effect of this new connection then throws a relay, stopping the motor magnet *MM*, and the arms *F*, in finder A, come to rest upon the contact corresponding to the line Y in Fig. 4.

The next step is for the subscriber to rotate the calling device, as already described, giving the correct number of impulses to operate the motor magnet on the first selector B in Fig. 4, sufficiently far to meet the contact in B, leading to one of 10 second selectors, *C'* in Fig. 4. The succeeding set of impulses sent in by the subscriber will operate the motor magnet in *C'* a number of steps corresponding to the number of impulses in this set, turning the switch in *C'* up to the next desired contact. When this second set of impulses is being sent over the line the first selector switch B has no tendency to rotate farther, because when it came to rest a slow relay in first selector B was allowed to operate and throw what is called the auxiliary or "side switch," in B (shown at X, Fig. 2), which cuts out the motor mechanism in first selector B, thus giving it no tendency to rotate farther for succeeding sets of impulses.

After the second set of impulses has been sent over the line the auxiliary switch on second selector *C'* does the same thing for this switch, and when the calling subscriber sends out the third set of impulses

X on this connector switch, which leads to the subscriber that it is desired to call.

This, then, makes the connection complete through from one 'phone to the other, and the last operation is the fourth turning of the calling device which operates the ringing relay (*K*, Fig. 2) in the last connector switch, which throws current through the line X to ring the bell on that particular telephone. As soon as this subscriber answers, the conversation may be continued as long as desired, and when completed the receivers are hung up in the usual manner. The hanging up of the receiver causes the operation of the release magnet in each switch, which has already been spoken of, and this allows the switch arms on all the various switches to swing back to the left-hand or off position, thus breaking the connections. In this way it is seen that any one subscriber connected to finder A can first make connections to the first selector, which in turn will connect him to any one of 10 second selectors. This second selector will



FIG. 5.—AUTOMATIC SWITCHBOARD AT URBANA, OHIO, HANDLING 1,500 SUBSCRIBERS. THE AUTOMATIC TELEPHONE CENTRAL.

considerable complication into the system, but the principles upon which it operates are beautifully simple when carefully studied, although the connections made are indeed exceedingly complicated. If the individual 'phone called should happen to be busy, a relay (L, Fig. 2) in its connector will automatically give the "busy tone" to the calling subscriber, and furthermore, it is impossible for any new connection to be made to a busy 'phone, thus removing this common source of annoyance in manual telephone service.

With such a diagram as that shown in Fig. 4, allowing only one person out of 50 to talk to any one of 5,000, and with the explanation of there being further switches for the use of other people who may be talking at the same time, the impression may be produced that the number of switches would necessarily be almost unlimited. This is, however, not correct, for with a system of, say, 5,000 subscribers, any six of which in every 50, or 12 per cent, may be talking at the same time, there are required only 2,400 instruments, counting the finders, the first and second selectors, and the final connectors.

For the purpose of illustration in this article, 5,000 'phones have been assumed. It must not for a moment be supposed, however, that this is the practical limit to automatic operation. By the addition of further switches in direct proportion to the 'phones added, any number of 'phones may be automatically controlled.

THE CENTRAL AT URBANA, OHIO.

The Independent Telephone Company, of Urbana, Ohio, with 1,500 subscribers, is now using a central manufactured by the American Automatic Telephone Company, and the perfection and certainty with which this central office operates is most astonishing. There appear to be no complaints on the part of the people using these telephones and there is no hesitancy in proclaiming the system an entire success. As already intimated, this automatic system allows six persons in every 50, or 12 per cent, to talk at one time. Ordinary manual practice gives only 10 per cent.

In the central office in Urbana there is a further provision made so that any subscriber in town on the automatic centrals may, by calling up a special selector switch by a suitable number of impulses, be connected directly to what are known as the "farmer switches." These farmer switches make connections to the various farmers in the surrounding country, and when this connection has been made, by turning the calling device a longer or shorter distance, various code rings of a long and a short, or two longs and two shorts or a long and two shorts, or any other system of code ringing may be produced so as to call any desired farmer on a party line having, no matter how many instruments in series, depending upon the system in use. If a farmer wishes to call up a town subscriber, he rings up on his own magneto calling an operator in the central office. This operator has in front of her a calling device of the automatic system leading to all of the subscribers in town and by properly turning the lever of this calling device, as already described, she can pass the connection on to any one of the town subscribers to whom the farmer desires to talk.

This same principle of having an automatic system in combination with a manual operator enables extensions to be made to existing manual systems, as by putting a large number of automatic machines at the disposal of the manual operator any connection may be made from the automatic to the non-automatic parts of the service. This has been done in a number of instances resulting in very greatly extended possibilities for manual switchboards which had already reached their limit of growth. It should be remarked in passing that with a manual system, if the switchboard is entirely filled up, it is necessary

before any further manual extensions can be made to entirely tear out that board and put in another one of larger proportions, because there are connections termed "multiples," located above the regular connections, which must be made whenever another panel of connections is added, and which it is impossible to put into the existing board. In this one feature of extension, the automatic device has an obvious advantage over the manual board, because in order to extend the automatic system, it is necessary only to add another bank of instruments without disturbing the connections of those already in.

GETTING AT THE SWITCHES.

Another one of the principal features of these automatic devices is the fact that the switches of the central office are so designed that in case one of them should become deranged, it is necessary only to pull it out by hand and insert a duplicate switch in its place simply by pushing it in. This construction is shown at the right of Fig. 2. All the connections to the switches are made by means of "jacks," which push in and out in this way, and it is not at all necessary to disturb the soldered wire connections at the back. In this way a couple of inspectors are able to take care of a very large installation by simply pulling out and replacing the various switches as it is found necessary to inspect them. If any one switch is defective, it may be repaired while a duplicate is in its place. This feature alone is of tremendous importance in such a thing as an automatic telephone central, for it insures that the whole apparatus be in first-class working order, and that there is no necessity for any part of it to become out of order on account of the necessity of putting the whole board out of operation, or in fact, any part of the board, while repairs are made.

It should further be said that this system employs what is known as harmonic bell ringing; that is, with a party line of say four subscribers it is perfectly possible to ring the bell only of the subscriber desired, while the other bells on the same line are silent. Harmonic bell ringing is obtained by the use of alternating current for ringing, these alternating currents being of different frequencies. For four bells on a line there would be one generator giving a frequency of 16 2/3 cycles per second, another of 33 1/3, another of 50, and another of 66 2/3 cycles per second, and by the device of using bell clappers of various weights, only that clapper which would have a period of vibration corresponding to the period of impulses of the magnetism given to it by the alternating current of any one frequency will be caused to ring. The other clappers being of greater or less frequency of vibration than the magnetism, would not vibrate and so these bells would not ring.

METERED CONVERSATION.

At the present time in all telephone work, whether of the manual or automatic type, there is a desire for what is known as "metered" service, that is, the telephone to be paid for according to the number of minutes it is in operation. For this purpose the American Automatic Telephone Company has a complete system of metering devices which they have perfected and which they are ready to furnish as soon as required.

For private lines they have an arrangement in the central office driven by a motor which will add up the total number of minutes during the month that the telephone is in actual use, and the charges to the subscriber are based on the record of this meter. For pay-station service they have another motor-driven meter arrangement which is equipped with commutating contacts on several disks, these contacts being spaced at different intervals on the different disks and arranged in such a way that they will collect money at a rate proportionate to the price of the call and

the length of time that the telephone is in operation. For instance, suppose a person wishes to telephone to a suburb, the price of the first three minutes, say, being 10 cents and each succeeding three minutes 5 cents. In the hopper of a little box in the booth he places a number of nickels. By means of the regular calling device he can obtain the line of the person to whom he wishes to speak. As soon as the connection is made the metering device automatically drops 10 cents from the pile of nickels into the receiving part of the box. This does not happen, however, until the subscriber at the far end has answered the 'phone by taking off his receiver.

When the first three minutes are up the metering device, by means of the disk contact in the central office, automatically takes another nickel and drops it into the bottom of the box. This allows the subscriber to talk for three minutes longer. At the end of the next three minutes another nickel is automatically dropped into the box from the pile in the hopper. When the conversation is ended and the receiver is hung up whatever money is left in the hopper is automatically dropped out into a tray and the subscriber may then put the change back into his pocket. If, while the conversation is going on, the supply of money in the hopper should give out, the connection through to the other 'phone is not lost, but the person at the far end cannot hear what is being said to him, although the person at the paying end can still hear and thus understand very quickly that his conversation is not being transmitted, this being the signal that he should drop more money into the hopper. As soon as the next nickel is dropped in the connection is made again so that both parties can hear and talk as usual. The connection not being entirely lost until the receivers are hung up, the trouble of calling a second time, in case the money should give out, is entirely avoided, and also it is not necessary to make another original payment of 10 cents as was done when the first connection was made.

In some districts it is customary to have a cheaper rate for night than for day service, and in order to take care of this there is a switch in the central office which may be turned by the wire chief after a certain time, say 6 o'clock in the evening, when the rate may be cut in half or into any other fraction; that is, the length of time allowed for conversation for one 5-cent piece is doubled or tripled, as the case may be. This again shows that there is no feature in connection with telephone service that cannot be taken care of by an automatic device.

It may be objected that this automatic metering system will make "too much money" for the telephone company because it very often happens that girls in the central office of a manual system forget to call for a second nickel. It is, however, more just to the subscriber as well, for everybody is treated exactly alike and especially so in the case of a private telephone where a short conversation does not cost as much as a long one, because of the use of the time-adding meter. In fact, it would seem that metered telephone service is just as desirable as metered gas service, for no gas consumer wishes to pay at a flat rate when he knows he is not consuming as much gas at one time as he is at another, or as much as his neighbor is, with the same number of jets.

Fig. 5 is a view of the switchboard in the central office at Urbana. This switchboard handles 1,500 subscribers, and the photograph shows the compact form in which the switches are arranged, and how easy of access they are for inspection and repairs.

It is thoroughly realized in the Middle West that the automatic telephone central is a thing of the very near future, and there is little doubt that in a few years all of the work which is now done by the manual centrals will be done by the automatic instruments.

PHOTOGRAPHS OF LUNAR AND SOLAR RESEARCHES.

PROF. W. H. PICKERING OF HARVARD has published the results of the photometrical researches which he has conducted at the station of Mandeville. In order to compare the luminosity of the sun with that of a star, a comparison which, for several reasons, cannot be made directly, Pickering compared both the sun and the star with a pentane lamp of one candle-power. The following very bright stars were used in making the comparison:

	Magnitude.	Color.
Arcturus	+0.24	Red
Capella	+0.21	Yellow
Vega	+0.14	Blue
Sirius	-1.58	Blue

Stars are classified in magnitudes, according to luminosity. The addition of 1 to the number (positive or negative, entire or fractional) which denotes the magnitude is equivalent to the multiplication of the luminosity by a constant factor (about 2.5). Thus Sirius, the brightest of all stars, is of the magnitude -1.58, and is 4.29 times as bright as a star of magnitude zero.

Prof. Pickering used a shadow photometer, and thus avoided the necessity of working in total darkness. A screen was arranged to receive two shadows of a needle, one being thrown by the pentane lamp, the other by the image of the sun as seen through the great telescope. The lamp was moved until the two shadows became equally deep, and the distance between the lamp and the screen was measured. The lamp and the sun were compared by the same method, the brightness of the solar image being reduced in a known ratio by the insertion of a small diaphragm. From these observations the stellar magnitude of the sun is easily calculated.

The values found for this magnitude range from -26.37 to -27.12. The mean value is -26.83, which differs little from the values computed by Gore, Dufour and Cerasaki.

A star of the 10th magnitude, invisible to the naked eye, is equivalent to one candle at a distance of 52.6 kilometers (nearly 33 miles), or to one million candles at a distance one thousand times greater (52,600 kilometers or 32,700 miles). From the known distance of the sun and its stellar magnitude, -26.83, it can

be calculated that the sun's candle-power is represented by the enormous number 4.38×10^{27} .

In 1901, Prof. Pickering made 26 measurements of the luminosity of the moon. No telescope was used. The observer carried a portable photometer and moved away from the building containing the pentane lamp until the lamp and the moon formed shadows of equal intensity. The distance between the observer and the lamp was measured by triangulation, and the moon's distance was obtained from the lunar tables.

In this way it was found that the full moon is equivalent to 100,000 stars of magnitude zero, or that its stellar magnitude is -12.5. At the first and third quarters, the luminosity is diminished to 1/12 that of the full moon, and the stellar magnitude becomes -9.8.

From these determinations it follows that sunlight is 540,000 times as intense as the light of the full moon. The sun is equivalent to 196,000 candles at a distance of one meter, the moon to 0.363 candle at the same distance. The moon's albedo, or power of reflecting diffused light, is equal to 0.0909, or to the reflecting power of rather dark colored rocks.

HOCUS POCUS MUTTERINGS.

SOME OLD CONJURERS' FORMULÆ AND MAGIC UTTERANCES.

BY ARTHUR WATSON.

THE conjurer of the present day usually attempts to interest his spectators, not merely by the tricks which he performs, which in many cases would speak for themselves, but also by his accompanying remarks. There is often very little need for his explanation, and conjuring may be effective without speech. The employment of patter may to some extent be regarded as a survival from times when words were used to impress beholders with a sense of mystery, and to lead them to suppose that the conjurer was associated with spirits or demons, by whose aid the trick was thought to be effected. In a number of cases we find instances of the actual use of mysterious words which were used as though they had some inherent power, or, on the other hand, as a kind of fluent talk employed for the purpose of heightening the effect or of diverting the attention of the beholders at that moment when the sleight is performed. St. Gregory Nazianzen uses the expression *λογος φηρολογικος* which may be taken to mean words such as the *acetalarius* would use. Roger Bacon has several references to the charms used by conjurers who make use of *circulos et characteres vanissimos et carmina stultissima et orationes stultissimas*.^{*} It may be noted in passing that, although Bacon disapproves of the use of charms and enchantments when they are inefficacious and used merely for display, yet he admits that there are certain genuine *deprecationes* instituted by men of truth or ordained by God and angels as, for instance, those used in ordeals over the white hot iron or the waters of a stream, and in other ways by which men are shown to be either innocent or guilty.

Again, in his "Opus Majus" (vol. I., page 399), in speaking of the power of words, he says that they have the greatest efficacy of all things, and that almost all miracles which have been performed by holy men from the beginning of the world have been done by the virtue of words. Further, he admits their use as justifiable in medicine, and quotes Constantine as approving of them, not because they have any real physical value, but because they render the patient more ready to take his medicine, and give him a more abundant hope of recovery, inasmuch as the mind has great power over the body.

Frohmann, in his "Tractatus de Fascinatione novus et singularis," 1675, quotes Riolanus Pater as stating that he had often found epileptics rise if the following lines were whispered thrice:

Gaspar fert myrrham, thus Melchior, Balthasar
aurum,
Haec tria qui secum portabit nomine Regum
Solvitur a morbo Christi pietate caduco;

and Wier, in "De Praestigiis," gives the following against toothache:

"Galbes galbat, galdes, galdat."

Fretagus writes, "It is said that toothache can be stopped if during the sacred offices the teeth are made to meet, and meantime these words are muttered:

"Os non conminuetis ex illo,"

or if this ridiculous phrase is hung round the neck:

"Strigiles falcesque dentatae, dentibus dolorum
persanate."

Against the bite of a mad dog the following was supposed to have efficacy:

"Irloni Khirioni efferat, Khuder fera;" and
"Hax pax max Deus adimax."

Casaubon, in a note in his "Animadversiones in Athenaei Deipnosoph.", describes the *jeux de gobelets* of his time as performing in such a way that the beholders, not knowing how the tricks were done, thought that they were achieved by virtue of the words which the conjurers poured forth or by some other magic power.

Scot, in his "Discoverie of Witchcraft," gives as an example of words which may be used in a trick with balls the following:

"Hey, fortuna, furie, nunquam credo, passe,
passe, when come you, sirra?"

and the "excellent feat to make a two penie piece lie plaine in the palme of your hand, and to be passed from thence when you list," he suggests might be accomplished by such words as:

"Allif, easyl, zaza, hit mel meltat: Saturnus,
Jupiter, Mars, Sol, Venus, Mercurie, Luna;"

^{*} "Miracles of Art and Nature."

or in transforming or altering the color of one's cap or hat:

"Droch myroch, & senaroth betu baroch asma-
roth, rousee farounsee, hey passe passe."

Neve, in the "Merry Companion," gives as the fourth of the requirements of a conjurer the following: "He must also have his terms of art; namely, certain strange terms and emphatical words to grace and adorn his actions, and to astonish the beholders; and these odd kinds of speeches must be various, according to the action he undertakes."

An expression which is very commonly associated with the conjurer is "Hocus Pocus." An early use of the word is to be found in a disputation of Voetius "De Magia." It is dated 1636. "Agyrtæ," the writer says, "call this vain and idle art 'Okos Bokos,' words taken from the real or imaginary name of an Italian priest or mystagogue, or from some other source."† Nares confirms this as the source, saying that their origin seems to be rightly drawn from the Italian jugglers, who said "Ochus Bochus" in reference to a famous magician of those names, and in a German book, "Etwas für alle," by Abraham a S. Clara, it is said that the conjurer was formerly called "Okos Bokos," the real or assumed name of an Italian who must have been an extraordinary master of this art. It may be noted that foreign writers in various instances have used the expression in forms which are further removed from that form which has been the basis of the supposed derivation as a corruption of *hoc est corpus*.‡

In a book entitled "Saltzame Gerichtshandel," by Matth. Abele, 1635, the author, in drawing a comparison between conjuring and the law, says that he has found, after industrious inquiry, that a certain Zolius had likened the "Högges und Pogges" of the conjurer to the "distorted and ambiguous speech of the lawyer."

Joachim Rachel, in his "Neu-verbesserte teutsche und satyrische Gedichte," has the following:

"Was mit der Langenzeit sol wachsen und bestehen,
Das muss nicht okes bokes wie aus der Taschen gehn."

Again, J. B. Schuppe, in his "Schriften," 1660, says that men who prefer vain and idle speculation and disputation are like rope walkers and jugglers. It is an art of walking on the rope; it is an art of playing various tricks, such as Joan Pottage or Ockes Bockes of Amsterdam used to perform.

The second edition of "Hocus Pocus Junior" (the earliest in the British Museum) was published in 1635. That the expression was no doubt in existence before that time may be argued from the facts—(1) that it was the second edition which was published in 1635, and (2) that the word "Junior" implies a predecessor who was senior, and indeed, the writer, in describing one of his tricks, refers to his "bonus genius" or "nuntius invisibilis" or "hiccius doccius" "as my senior calls it." Again, Ady, writing in 1656, speaks of "one man more excellent in that craft (conjuring) than others that went about in King James's time, and long since, who called himself the King's most excellent Hocus Pocus; and so was he called because, at playing every trick, he used to say 'Hocus Pocus, tontus talontus, vade celeriter jubeo.'" This, if it may be accepted, takes back the expression at least a further ten years.

Further, Ben Jonson, in "Magnetic Lady," acted in 1632, uses the expression Hokus Pokos in the following passage from the chorus at the end of the first act:

"Boy: Do they think this pen can juggle? I
would we had Hokus Pokos for 'em then,
your people, or Travittanto Tudesco."

"Dampplay: Who's that, boy?"

"Boy: Another juggler with a long name."

Here it may be noted that Hokus Pokos is coupled with an Italian name, and, further, that it is in form near to that given by Voetius.

The foregoing references lead one to suppose that Hocus Pocus was an expression in varying forms which was generally known in the middle of the sev-

^{*} Richard Neve, in his "Merry Companion," 1716, gives "allif, easyl, zaza, hit mel meltat, Saturnus, Jupiter, Mars, Venus, Mercurie, Luna; and Dorocet, Micocti et Senarocet, veld, barocet, Asmarocet, Rounsee, Farounsee, hey pass pass," etc.

† Voetius, lib. 2, "Diapp." p. 542.

‡ The date of the sermon of Tillotson, in which he says that in all probability these juggling words are nothing else but a corruption of the words used by the priests of the Church of Rome in their tricks of Transubstantiation, is 1694. This derivation appears to be a quite gratuitous invention.

enteenth century, not only in England but abroad, and there is evidence of a kind that it was known at least as early as 1625. It would not be surprising to find the words in use at an earlier date. The earliest suggestion of a derivation, viz., that referred to as given in Voetius under the date 1636, is that Italy is the source of the expression, and that it was probably the assumed name of a man.

As derivations have been suggested the Welsh *hocoed*, a cheat, and *bug*, or *pwca*, a hobgoblin, and the French *hocher*, to stake, and *pocher*, to poke; but these derivations are not to be taken seriously. Further, the second word "pocus" is almost without doubt a reduplicated form of the first, and for quite analogous reduplications may be quoted "higgledy-piggledy," "hurly-burly," "hickery-pickery," and "hokey-pokey." Analogous to the reduplication in "hiccius doctus" may be mentioned "handy-dandy," "holty-toity," "humpty-dumpty," "hobby-doddy," and "hickery-dickery."

The little wooden man used in a vanishing trick is called "Hiccius Doctus." The trick is represented in the "Hocus Pocus Junior," and in the frontispiece to the "Hocus Pocus," which forms part of a German book entitled "Das Zeitkurtzende Lust- und Spielhaus (in Fig. 10) where the trick is fully described, the conjurer saying: "Look, gentlemen, this man I call Bonus Genius, or Hiccius Doctus," and at the end he says, "Hei genius meus velocissimus ubi."

Hiccius Doctus is the frontispiece of the second edition of "Hocus Pocus Junior, or the Anatomie of Leg-erdemain," and is referred to in the preface to that book as follows:

"Courteous Reader, doe you not wonder? If you doe not, well you may, to see so slight a pamphlet so quickly spent; but lightly come and lightly goe, it's a Jugler's terme, and it well befits the subject. Would you know whence it first came? Why, from Bartholomew Fayre. Would you know whither it's bent?—For the Fayre again: it's a stragler, a wanderer, and, as I said, as it lightly comes, so it lightly goes; for it means to see not onely Bartholomew's Fayre, but all the Fayres in the Kingdome also, and therefore in the front. Hiccius Doctus is the postmaster, and what he wants there I'll give him here—a word or two of command, a terme of art not so much substantiall as circumstantiall. Celeriter, vade, over hedges and ditches, thorow thicke and thin, to come to your Fayres."

In this preface we may suppose that the author is writing with the same kind of inconsequence as the conjurer speaks at the fair. The expression Hiccius Doctus is said to be a corruption of *hic est doctus*.

Various aspects of conjuring have been emphasized in the different names attached in different languages to the performer of tricks of legerdemain. The Greeks called him the *φροδοκτακτς* from the pebbles which he used. Similarly the Romans styled him the *calcularius*, or *acetalarius*,^{*} from the little stones and cups respectively. In French he is the *jeu de gobelets*, and the French *escamoteur* comes from *escamot*, a cork ball, and has reference to the cup and ball trick. Again, he was the *saccularius*, or bag-man, just as in German he is the *Taschenpieler*, so called from his way of hiding objects in his pocket or bag. Similarly in Italian he is the *bossetino*, or purse-man, and Voetius, in his disputation "De Magia," gives as the Flemish for conjuring *uyt den assack spelen*. In French he is the *prestidigitateur*, from the readiness or quickness of his fingers. In English *conjurer* refers to the calling of spirits to his aid, and *juggler*, which is often used for conjurer, is derived from the Latin *joculator*, which is in Italian *giocolatore*, and in French *jongleur*. Another German word, *Tausendkünstler*, refers to the variety of his tricks, while the English *regitour* originally refers to the mechanical contrivances used by the conjurer, though this original meaning is not evident in the following passage from Lydgate's "Dance of Macabre," where the word is equivalent to conjurer:

"Maister John Rykell, sometime regitour of
noble Henri, Kinge of England.

And of France the mighty conqueror;

For all the sleighes and turnyng of thyne honde,
Thou must come nere this dance to understonde.

Nought may avail all thy conclusions

For deth shortly, nother on see nor longe.

Is not dysceyved by noon illusions."

^{*} An analogous denomination is the English "thimble-rigger."

The following is a list of references to representations of feats of conjuring:

BOOK ILLUSTRATIONS OR PRINTS.

- Block-book in the British Museum, German, 1475. "Planetenbuch," under Luna (see Fig. 2).
 Florentine engraving ascribed to Baccio Baldini (see Fig. 3)—Conjurer at table in special dress, an ape at his feet. Lippmann, "The Seven Planets," 1905.
 Block-book in Berlin Print Room, 1470. Luna. Lippmann, "The Seven Planets"; Hampe, "Fahrende Leute," 1902, opp. p. 28.
 Mediaeval House-book in Prince Waldburg-Waldsee's collection at Wolfegg in Wurtemberg. Lippmann, "The Seven Planets"; Hampe, "Fahrende Leute"; A. Schultz, "Das Höfische Leben."
 Hans Sebald Beham—engraving (see Fig. 4). Lippmann, "The Seven Planets"; G. Hirth, "Kulturgeschichtliches Bilderbuch," vol. i, p. 290.
 Scot, Reginald, "The Discoverie of Witchcraft," 1584 (see Figs. 6 and 7).
 Petrarch, "Von der Artzney Bayder Glück," 1532, (see Fig. 5).
 "Hocus Pocus Junior," 1635—various illustrations (see e. g., Fig. 9).
 Comenius, "Orbis Sensualium Pictus," 1659, p. 266 (see Fig. 12).
 "Das Zeitkurtzende Lust- und Spiel-Haus," 1680—various illustrations (see e. g., Fig. 10).
 Abraham a S. Clara, "Etwas für Alle," 1711, 3rd part, p. 944 (bird trick); p. 954, "Der Wasser Speyer"; p. 906, fire eater.
 Print in British Museum, Class X P. 7—Robert Neve and bird trick (see Fig. 11).
 Print in British Museum—Foreigners in England, case 2. Floram Marchand, "Le Grand Boyeur de Tours," 1650 (see Fig. 8).

LAMPS.

- Roman Lamp—Roman and Greek Life Room, case J. No. 217 (see Fig. 1). H. B. Walters, "History of Ancient Pottery," 1905, vol. II, opp. p. 416, plate lxx (see Fig. 2).
 Licetus, "De Lucernis Antiquorum," 1562, p. 887; Bartoli, "Lucerne veter."
 "Revue Archéologique," 1898, p. 233.

WALL PAINTINGS.

- Conjuring with cups and balls. Wilkinson, "Manners of the Ancient Egyptians," 1878, vol. II, p. 70. —The Reliquary and Illustrated Archaeologist.

TRADE NOTES AND FORMULÆ.

Insulating Cement.—2 parts Grecian pitch and 1 part of well-calced gypsum, are melted together. As long as the cement is warm it can be kneaded and worked plastically; when cold it can be turned in the lathe and polished.

Copy Paper, Blue or Black.—Take fine lamp-black or ivory black, indigo, carmine, or ultramarine, mix one or other of these coloring substances thoroughly with soft soap and by means of a stiff brush, apply the mixture thus obtained to thin but strong paper, by which means it is said a much better copying paper can be produced than the carbon sheets made with fatty oils.

Fire-proof Canvas for Tents.—Allow 100 parts of water to boil and in a tub place 14 parts of chemically pure sulphate of ammonia, pour part of the boiling water on it and add afterward 1 part each of boracic and hartshorn salts, 3 parts of borax, and 2 parts of glue water, in the order given. Then add the remainder of the hot water. The tub should be kept covered until solution is complete.

Wagon Grease.—I. The German grade "Finest" or "Natural Color" consists of 75 parts light blue oil, 10 parts of slaked lime, and 15 parts rosin oil. II. "Excelsior" rosin grease ("Prime Violet Oxidizing") is composed of 64.5 parts light blue oil, 9.5 parts slaked lime, and 12 parts each of codfish oil and rosin blue oil. III. "Lubricator" (prime bright black) consists of 36 parts each of prime blue oil and naphtha residue, 12.5 parts lime and 16.5 parts rosin oil. IV. "Mercantile," black, consists of 20 parts seconds blue oil, 23 parts naphtha residue, 8.5 parts lime, 40 parts gypsum, and 8.5 parts of rosin oil. The mineral oil must be mixed with the dry lime and thereupon, after standing at least half an hour, the mass strained into the shipping package, the operation being aided by stirring with a board. Then the remaining components, with the exception of the rosin oil, are added; stir vigorously for a time, and finally, stirring continuously, add the rosin oil, whereupon the mass, after a short time, solidifies. It is advisable always, by means of a small preliminary test, to determine how much rosin oil is needed to insure the requisite buttery consistency. The lime used must be fat, as otherwise the saponification would proceed too slowly and, in addition a smeary and dull product might result. For coloring, wine-black, or aniline colors soluble in grease in proportion of 1 to 100, dissolved in mineral oil, heated to about 175 deg. F., may be used. Care must be taken to use, for light-colored wagon grease, the palest possible oils.

ENGINEERING NOTES.

The new Leblanc refrigerating apparatus consists of a steam turbine, employed as a condenser, and used in connection with a steam ejector, by which a partial vacuum is created above an absorbent mass saturated with salt water. The rapid evaporation thus produced causes a correspondingly rapid abstraction of heat, amounting to 360, 196, or 110 calories per kilogramme of steam used, according as the initial temperature of the brine is 39, 23, or 14 deg. F. The steam, condensed to a pressure of two atmospheres before ejection, acquires in expanding a velocity of nearly 4,000 feet per second.

Concrete has been successfully employed in the construction of tunnels, and it has been suggested as a substitute for wooden beams for supporting mine galleries. The first attempts were made by surrounding with concrete the small beams of the sides of the gallery, the roof being formed of beams inclined toward each other, and the cement forming a continuous sheet of arched form springing from the floor. The wood was then replaced by iron rails similarly imbedded in concrete, which in this case was extended to cover the floor of the gallery; thinner layers, however, being employed for the floors and the roof than for the sides. In another system the concrete forms only a covering of a masonry arch. Galleries of various shapes have been formed of compressed ferro-concrete, but the most original method consists in replacing the masonry of a mine shaft by three concentric tubes formed of contiguous concrete pillars. In many cases concrete construction will be found both effective and economical.

According to a consular report dealing with the trade and commerce of the vilayet of Aleppo, the Beyrout-Rayak-Aleppo railway has proved not to be in a position really to help the development of trade of the Aleppo vilayet. This railway has a length of about 312 miles and is divided into two sections. The first section is a narrow-gauge line and extends from Beyrout to Rayak in the Anti-Lebanon. The other section, a broad-gauge line, starts from Rayak and terminates at Aleppo, passing through Homs and Hama. Aleppo goods have to be transferred at Rayak, where they are exposed to delays and damage. For this reason the port of Alexandretta is still attracting the bulk of the trade, as it constitutes the natural and the most direct port for the Aleppo and Mesopotamian vilayets. The inhabitants of the vilayet of Aleppo, since the proclamation of the constitution, are strongly and persistently claiming from the Ottoman government the prompt construction of the Alexandretta-Aleppo railway. It seems that the government has now taken their demands into serious consideration, as there is at present an idea of carrying the main Bagdad line from Adana through Alexandretta to Aleppo. Such a line would no doubt immediately manifest its commercial and economical importance.

The cost of cutting steel and iron with saws of various kinds and with the oxygen-gasoline blowpipe is compared in the following table, published by a French railway journal. In each case the cross-section of the bar is 100 square centimeters, or 15½ square inches.

Tool.	Cost.		Time required.
	Cents.	Minutes.	
Hand saw	32 to 58	45 to 75	
Power saw, single cut..	25	60	
Power saw, triple cut..	14	60	
Oxy-gasoline blowpipe..	6	1	

The substitution of the blowpipe for the saw, therefore, effects a great saving in time as well as in money. The blowpipe used in these experiments terminated in a circle of small holes, through which oxygen and gasoline vapor were forced. The gasoline vapor was delivered at a pressure of 2 atmospheres, while the pressure of the oxygen ranged from 3 to 12 atmospheres. The proportions of oxygen and vapor were regulated by cocks on the two supply pipes. The actual cutting was performed by a jet of pure oxygen, blown through a central orifice. The thickness of the cut, usually 1/6 inch, could be varied by varying the diameter of the jet. The pressure of the oxygen was regulated in accordance with the depth of the cut, 3 atmospheres being required for 1 inch, 6 or 7 atmospheres for 2 inches, and 12 atmospheres for 6 or 8 inches. The liquid gasoline was forced into the burner, under a pressure of 2 atmospheres, by a hand pump, and was volatilized by an auxiliary flame. In cutting small bars the blowpipe was held in the hand, with the aid of a guiding wheel, but for larger operations it was attached rigidly to a slide which traveled along a screw 10 feet in length, which was turned in either direction, as required, by an electric motor. A special advantage of the blowpipe is its ability to cut the hardest specimens of chrome steel and manganese steel which cannot be sawed, and its indifference to hard particles which make it necessary to change saws during a cutting.

ELECTRICAL NOTES.

The steel furnaces in existence and in process of construction, in the entire world, number 78, and include 35 induction furnaces, and 43 arc and resistance furnaces. The various types are represented as follows: 1 Colby, 3 Swedish Electrometallurgical Company, 1 Hiorth, 1 Keller, 14 Kjellin, 10 Roehling-Rodenhauser, 1 Schneider, 1 Schneider-Gul, 11 Stassano, 1 Wallin. There is a strong tendency to increase the size of the electric furnaces. Some furnaces of 8 or 10 tons capacity have already been constructed.

Backland has produced from coal tar a new insulating material which is called backelite, which can be made either transparent or opaque. Its electrical resistance is higher than that of celluloid or India rubber. Backelite is, furthermore, remarkable for its resistance to acids and its infusibility. It does not even soften when heated to 660 deg. F., and it carbonizes without melting at the temperature of fusion of glass. The coils and other objects which are to be insulated are covered with the raw materials from which the backelite is made, and are then heated under pressure, producing a very hard, solid mass and perfect insulation. This insulator is said to have given excellent results in regard both to mechanical strength and electrical resistance. It can be combined without difficulty with clay, asbestos, wood pulp, and other inert fillers. In addition to its employment as an insulator, backelite is useful for giving hardness to wood, protecting wooden vessels from the action of acid or hot solutions, and in packing stuffing boxes of pumps for acids, and steam engines using superheated steam.

The system to be adopted for conveying electrical energy to great distances depends upon the regulation required for the final distribution. Electrical energy is now transmitted without difficulty to a distance of 125 miles by means of a triphase current of 60,000 volts and 50 cycles per second. For greater distances the frequency of alternation must be reduced, but it must then be increased again in the distributing system, and this cannot be done at present without loss of energy. The simple alternating system has lately been substituted for the triphase system, especially for electric traction. High voltage is economically advantageous, but the voltage is limited by the insulation. Subterranean cables cannot carry alternating currents of much more than 100,000 volts, although, with a direct current, the voltage may be increased to 300,000. An interesting system employs direct and triphase current conjointly. The various distributing systems are connected and the generating stations mutually supported by means of the triphase current, which supplies the distributing systems with direct current by means of rotary converters.

It is only within very recent years that the London County Council would entertain the idea of adopting the trolley wire. Only a few examples of the latter system have been put into use, and the latest of these is the Putney to Hammersmith line. It is 2¼ miles long, and is practically level all the way. Regarding the disposition of the track, the only special feature is that on Putney Bridge, where the carriageway is somewhat narrow, and each track has been placed close to the respective footpaths. The near rail is 2 feet 6 inches from the curb, and the space between tracks, center to center, is 15 feet. The line is fed from a sub-station in Great Church Lane, two low-tension, single-core, lead-covered, paper-insulated cables being employed. The sub-station itself is no less than ten miles distant from the Council's generating station at Greenwich, and the system presents at present the longest transmission in connection with the London tramways. The pressure of the three-phase alternating current generated at Greenwich is 6,500 volts, and in the transmission to Hammersmith there is a drop of about 400 volts, or 6 per cent. The sub-station contains three motor generators. Two are of 500 kilowatts each, and one of 150 kilowatts, the latter being used chiefly as a starter for the larger machines.

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